# EXHIBIT B

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# DIAS INVESTIGATION COMMITTEE REPORT

# UNIVERSITY OF ROCHESTER

## REPORT ISSUED: FEBRUARY 8, 2024

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**INVESTIGATION COMMITTEE MEMBERS AND AFFILIATIONS (FOR IDENTIFICATION ONLY)**

| | |
|---|---|
| Peter Celliers, PhD | Staff Scientist<br>Lawrence Livermore National Laboratory |
| Marcus D. Knudson, PhD | Senior Scientist<br>Sandia National Laboratories |
| Marius Millot, PhD (Chair) | Senior Scientist<br>Lawrence Livermore National Laboratory |

Collectively, Drs. Celliers, Knudson, and Millot are referred to herein as the "Investigation Committee."

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## TERMINOLOGY

| Term | Definition |
|---|---|
| **arXiv** | Open-access archive and online publisher of scholarly articles and commentary; its contents are not peer reviewed |
| **CSH** | Chemical compound carbonaceous sulfur hydride; also used in the shorthand for the Nature 2020 (CSH) Paper |
| **C(T)** | Heat-capacity (or equivalently specific heat) as a function of temperature |
| **DAC** | Diamond anvil cell, a tool to create high pressures greater than 1 GPa |
| **GPa** | $10^9$ Pascals, a unit of pressure common in high pressure science<br>1 GPa=10kbar |
| **HPCAT** | High-Pressure Collaborative Access Team, a synchrotron-based facility located at the Advanced Photon Source ("APS"), Argonne National Laboratory |
| **infrared (IR) spectroscopy** | Measures absolute frequencies at which samples absorb radiation |
| **LabVIEW** | Laboratory Virtual Instrument Engineering Workbench, a computer programming language developed by National Instruments to control and interface with scientific instruments |
| **LuH** | Lutetium hydride, a chemical compound; also used in the shorthand for the Nature 2023 (LuH) Paper |
| **$MnS_2$** | manganese sulfide, a chemical compound; also used in the shorthand for the PRL 2021 ($MnS_2$) Paper |
| **PPMS** | Physical Property Measurement System; an open architecture, variable temperature-field system commercialized by Quantum Design, designed to perform certain automated measurements, including resistivity, heat capacity, ac/dc magnetometry, and thermal transport |
| **Python** | A computer programming language |
| **Raman spectroscopy** | A technique for observing vibrational, rotational, electronic, and other low-frequency modes in a sample |
| **R(T)** | Resistance versus temperature |
| **VSM** | Vibrating sample magnetometer; enables measurement of a sample's magnetization |
| **x-ray diffraction** | Technique used to determine a sample's composition or structure |
| **$\chi$(T)** | Magnetic susceptibility as a function of temperature |

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# I. INTRODUCTION

## A. Receipt of Allegations

An initial allegation of research misconduct was submitted on or around August 17, 2021, through the University of Rochester (the "University") Medical Center Research Integrity Hotline, and again on November 3, 2021 via the University's general compliance email address, in each case by Jorge Hirsch, PhD, Professor, University of California, San Diego (the "First Complaint"). Dr. Hirsch alleged that Liyanagamage (Ranga) Dias, PhD, Assistant Professor at the University ("Respondent") engaged in certain acts of research misconduct. In response to this allegation, the University conducted an internal inquiry ("Inquiry #1").

On January 20, 2022, John Tarduno, PhD, the University's Dean of Research, Arts, Science & Engineering, received an email complaint from Dirk van der Marel, PhD, Professor, University of Geneva (the "Second Complaint"). Dr. van der Marel alleged that Respondent had fabricated data and provided misleading information about data in the Nature 2020 (CSH) Paper (defined below).

On August 20, 2022 and September 30, 2022, Dr. Hirsch submitted additional complaints via email pertaining to the background subtraction method that Respondent used in the Nature 2020 (CSH) Paper (the "Third Complaint"). The Second and Third Complaints prompted the University to conduct additional inquiries into potential research misconduct associated with those allegations ("Inquiry #2" and "Inquiry #2A," respectively).

These complaints and associated inquiries are described further at Section I.C.

A timeline of events is attached hereto as Exhibit A.

## B. Papers, Patents, and Federal Funding Sources

Based on the allegations set forth at Section I.A above, as well as the NSF Letter (as defined and described at Section II.A below), the Investigation Committee focused its review on certain research of Respondent related to superconductivity and to insulator-to-metal transitions in certain materials, including carbonaceous sulfur hydride ("CSH"), manganese sulfide ("$MnS_2$"), and lutetium hydride ("LuH"). The results of these experiments are used to support certain papers and patents, and are related to specific federal funding sources, as set forth below.

### *Papers*

The manuscripts containing experimental data that are alleged to be fabricated, falsified, and/or plagiarized include, in order of publication:

- Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Mathew Debessai, Hiranya Vindana, Kevin Vencatasamy, Keith V. Lawler, Ashkan Salamat & Ranga P. Dias, *RETRACTED ARTICLE: Room-temperature superconductivity in a carbonaceous sulfur hydride*, NATURE 586, 373 (2020), https://doi.org/10.1038/s41586-020-2801-z (the "Nature 2020 (CSH) Paper").
- Dylan Durkee, Nathan Dasenbrock-Gammon, G. Alexander Smith, Elliot Snider, Dean Smith, Christian Childs, Simon A. J. Kimber, Keith V. Lawler, Ranga P. Dias & Ashkan

Salamat, *RETRACTED ARTICLE: Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator $MnS_2$*, PHYSICAL REVIEW LETTERS, 127, 1 (2021), http://dx.doi.org/10.1103/PhysRevLett.127.016401 (the "PRL 2021 ($MnS_2$) Paper").

- G. Alexander Smith, Ines E. Collings, Elliot Snider, Dean Smith, Sylvain Petitgirard, Jesse S. Smith, Melanie White, Elyse Jones, Paul Ellison, Keith V. Lawler, Ranga P. Dias & Ashkan Salamat, *RETRACTED ARTICLE: Carbon content drives high temperature superconductivity in a carbonaceous sulfur hydride below 100 GPa*, CHEMICAL COMMUNICATIONS 58, 9064 (2022), https://doi.org/10.1039/D3CC90410E (the "Chem. Commun. 2022 Paper").
- Nathan Dasenbrock-Gammon, Elliot Snider, Raymond McBride, Hiranya Pasan, Dylan Durkee, Nugzari Khalvashi-Sutter, Sasanka Munasinghe, Sachith E. Dissanayake, Keith V. Lawler, Ashkan Salamat & Ranga P. Dias, *RETRACTED ARTICLE: Evidence of near-ambient superconductivity in a N-doped lutetium hydride*, NATURE 615, 244–250 (2023), https://doi.org/10.1038/s41586-023-05742-0 (the "Nature 2023 (LuH) Paper").

Collectively, the Nature 2020 (CSH) Paper, the PRL 2021($MnS_2$) Paper, the Chem. Commun. 2022 Paper, and the Nature 2023 (LuH) Paper are referred to as the "Papers."

As of the date of this report, the Nature 2020 (CSH) Paper, the PRL 2021 ($MnS_2$) Paper, the Chem. Commun. 2022 Paper, and the Nature 2023 (LuH) Paper have been retracted. Respondent did not and has not supported retraction of any of these papers.

Separately, on December 7, 2023, Physical Review Letters ("*PRL*") posted an Expression of Concern related to a separate paper focused on yttrium superhydride, on which Respondent is corresponding and senior author.[1] The Investigation Committee did not focus on this paper as part of its primary review; however, this paper is discussed at Section IV (Additional Considerations) of this report.

A list of relevant publications and corresponding funding sources is attached at Exhibit B, and full copies of these publications are attached at Exhibit C.

***Patents***

The chart below summarizes those certain patents that pertain to subject matter overlapping with the Papers (collectively, the "Patents"), such that these Patents may be dependent upon the same or related data or information that are alleged to have been fabricated, falsified, and/or plagiarized data or information. The Investigation Committee was unable to confirm the contents of two provisional patents on which Respondent is a listed inventor, given the confidential status of those patents.

[1] Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Xiaoyu Wang, Noah Meyers, Keith V. Lawler, Eva Zurek, Ashkan Salamat & Ranga P. Dias, *Expression of Concern: Synthesis of Yttrium Superhydride Superconductor with a Transition Temperature up to 262 K by Catalytic Hydrogenation at High Pressures [Phys. Rev. Lett. 126, 117003 (2021)]*, PHYS. REV. LETT. 131, 239902 (Dec. 7, 2023), https://doi.org/10.1103/PhysRevLett.131.239902.

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| Patent Families with Respondent as an Inventor | | | | |
|---|---|---|---|---|
| **Title** | **International Application Number** | **National Stage Filings[2]** | **Priority Claim** | **Related Scientific Publication** |
| Superconducting Hydride Materials and Methods of Making and Identifying Same[3] | PCT/US2021/042447 | Australia, Canada, China, Europe, India, Japan, Russia, South Korea, United States | US63/054,105 and US63/054,111 (both filed 7/20/2020) | Nature 2020 (CSH) Paper |
| Superconducting Materials and Methods of Making the Same[4] | PCT/US2021/043785 | Australia, Canada, China, Europe, India, Japan, Russia, South Korea, United States | US63/058,324 (filed 7/29/2020) | Nature 2023 (LuH) Paper |
| High Temperature and Low Pressure superconductor | PCT/US2022/038408 | N/A[5] | US63/230,669 (filed 8/6/2021) | Nature 2023 (LuH Paper) |

***Federal Funding Sources***

The Papers associated with the allegations were supported by award funds from the U.S. government, including the following federal awards and support from the National Science Foundation ("NSF") and the Department of Energy ("DOE"):

- NSF, DMR-1809649 (PI: Ranga Dias, University of Rochester)
- NSF, DMR-1904694 (PI: Ashkan Salamat, University of Nevada, Las Vegas)
- DOE, DE-SC0020303 (PI: Ashkan Salamat, University of Nevada, Las Vegas)
- DOE, DE-SC0020340 (PI: Gilbert Collins, University of Rochester)
- DOE Stockpile Stewardship Academic Alliance Program, DE-NA0003898 (PI: Ranga Dias, University of Rochester)

Furthermore, at least two of Respondent's papers involve work conducted at HPCAT, a DOE-supported facility.

Separate from the papers at issue, Respondent's NSF career award proposal, DMR-2046796, (the "NSF Proposal") is alleged to include certain plagiarized material.

[2] All national stage filings claiming priority from an international filing include the same content as the international filing, translated into local language and revised per local patent laws, as applicable.
[3] The University co-owns with the University of Nevada, Las Vegas.
[4] The University co-owns with the University of Nevada, Las Vegas.
[5] The 30-month deadline for filing has not yet occurred.

As noted above, a list of relevant publications and corresponding funding sources is attached as Exhibit B.

## C. Inquiries

### *Inquiry #1*

Inquiry #1 was coordinated by John Tarduno, PhD, Dean of Research, and Stephen Dewhurst, PhD, Interim Vice President for Research, with review activities carried out with the assistance of three internal reviewers (Inquiry Reviewer 1; Inquiry Reviewer 2; and Inquiry Reviewer 3), as well as one external reviewer (Inquiry Reviewer 4). To the University's knowledge, none of the internal reviewers was involved with the research at issue in the inquiry. However, the Investigation Committee notes that Inquiry Reviewer 4 has collaborated with Respondent on multiple papers, alongside Inquiry Reviewer 6.[6]

Inquiry #1 focused on magnetic susceptibility data and background subtraction reported in the Nature 2020 (CSH) Paper. The inquiry was limited to review of magnetic susceptibility data at a few selected pressures as provided by Respondent. Formatting of the data provided by Respondent for this inquiry implied that the background had been measured independently of the "raw signal," as stated in the Nature 2020 (CSH) Paper, but this is in contrast with the later arXiv document in which Respondent described the background as being derived from the "raw signal."[7]

Inquiry #1 concluded with the issuance of a report dated January 19, 2022, which found that there was no credible evidence to warrant further investigation into research misconduct. Specifically, the internal, University-based reviewers found that, after examining the data provided, they "[did] not believe that the changes in AC susceptibility reported in [Respondent's] original Nature 2020 paper could be an artifact of the background subtraction," and that "[t]he differences between the sample and background measurements provided to [the reviewers] are quite small, but neither the data nor the background display variations are anywhere near the size of the signal shift at the apparent superconducting transition."[8] In addition, the external reviewer reported that, "[o]verall, . . . the data [he was] given does show what is reported in the [Nature 2020 (CSH) Paper] and that the background subtraction did not introduce the signature."[9]

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[6] *See, e.g.*, Anmol Lamichhane, Ravhi Kumar, Muhtar Ahart, Nilesh P. Salke, Nathan Dasenbrock-Gammon, Elliot Snider, Yue Meng, Barbara Lavina, Stella Chariton, Vitali B. Prakapenka, Maddury Somayazulu, Ranga P. Dias & Russell J. Hemley, *X-ray diffraction and equation of state of the C-S-H room-temperature superconductor*, J. CHEM. PHYS. 115, 114703 (2021), https://doi.org/10.1063/5.0064750.

[7] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017; Ranga P. Dias & Ashkan Salamat, *Reply to "Comment on Nature 586, 373 (2020) by E. Snider et al.,"* ARXIV (2022), https://arxiv.org/abs/2201.11883. *See* Section III.A of this report for further discussion.

[8] *See* Inquiry Report #1, Appendix 2 (Internal Report from Internal UR Reviewers) at Exhibit D.

[9] *Id.* at Appendix 1 (External Report from Inquiry Reviewer 4) (on file as 2021-12-01 Report of Somayazulu_Review of NSF 2020 (CSH) Paper [See also Inquiry Report 1, App 1].pdf). In email correspondence dated December 1, 2021, Inquiry Reviewer 4 sent a Word document with his findings to Respondent, Interviewee 7, and Tobias Roedel of *Nature*, which Respondent then forwarded to John Tarduno and Gilbert (Rip) Collins later the same day. *See* Email from Inquiry Reviewer 4 to Respondent, Interviewee 7, and Tobias Roedel, Senior Editor, *Nature* (Dec. 1, 2021) (on file as 2021-12-01 Email Somayazulu to Dias, Salamat, Roedel.pdf).

The University communicated with relevant funding agencies during Inquiry #1, as described in the report for Inquiry #1 (Exhibit D), including updates to NSF and DOE provided on January 3, 2022. The University also wrote to Drs. Hirsch and van der Marel on May 22, 2022 to let them know the outcome of the inquiry.

***Inquiry #2***

The University initiated Inquiry #2 in response to the Second Complaint. Inquiry #2 was conducted by Inquiry Reviewer 5 and Inquiry Reviewer 6.

Inquiry #2 focused on magnetic susceptibility data and background subtraction that was used in the Nature 2020 (CSH) Paper. Inquiry #2 concluded with the issuance of a report on April 6, 2022, and the reviewers found that no formal investigation was warranted but that the Nature 2020 (CSH) Paper should have an erratum to correct the ambiguities in the paper. Specifically, the reviewers summarized their findings as follows: (1) there was "[n]o evidence of research misconduct or falsification"; (2) there was "[a] definite lack of clarity in describing key measurement analysis methods, which were employed for no good reasons, verging on misleading due to omission of details"; and (3) that "[a] thorough publication describing the background subtraction methodology and errata on the Nature paper [is] warranted."[10,11] The reviewers also recommended that Respondent "should have an expert assigned as a resource to conduct discussions on data analysis, data error, and the use of synthetic data," and that the University "should also consider a senior mentor for [Respondent] to help navigate responses to allegations and critiques of publications."[12]

The report for Inquiry #2 was shared with NSF on June 15, 2022. The University also wrote to Drs. Hirsch and van der Marel on May 22, 2022 to let them know the outcome of the inquiry.

***Inquiry #2A***

Inquiry #2A was initiated due to the Third Complaint from Dr. Hirsch and the possible retraction of the Nature 2020 (CSH) Paper. This follow-up inquiry was conducted by Inquiry Reviewer 5 and included a review of Dr. Hirsch's complaint dated August 20, 2022, post-publication review comments from four referees, and the responses from Respondent and other co-authors.

Inquiry #2A focused on whether the Third Complaint or the impending retraction of the Nature 2020 (CSH) Paper and related post-publication review correspondence altered the earlier conclusion that an investigation was not warranted.[13] In his October 19, 2022 report, Inquiry Reviewer 5 concluded that this new information did not contradict the conclusions of Inquiry #2 and an investigation into research misconduct was not warranted. Specifically, he stated: "I have determined that most of the concerns raised by the post publication reviewers mapped to those considered and resolved during [Inquiry #2]";[14] and "[b]ased on this, I still conclude that the raw

[10] Inquiry Report #2 at Exhibit D.
[11] *See* Inquiry Reviewer 5/Interviewee 2 Interview (Aug. 8, 2023) 8:14-18 ("I concluded the raw data was real and that the background subtraction . . . introduced errors, signatures [and that] it was generally bad practice, and was definitely not explained in the 2020 paper").
[12] Inquiry Report #2 at Exhibit D.
[13] *See* Inquiry Report #2A at Exhibit D; *see also* Inquiry Reviewer 5/Interviewee 2 Interview (Aug. 28, 2023) 23-24.
[14] *See* Inquiry Report #2A at Exhibit D.

signal measurements are 'more likely than not' to be the actual measured response and all measurement artifacts are either noise or a result of the user-defined background subtraction methodology of [Respondent] *et al*."[15] During his interview with the Investigation Committee, Inquiry Reviewer 5 stated that he did not feel, at the time of his review, that Respondent was deliberately attempting to hide information from Inquiry Reviewer 5.[16]

Copies of the three inquiry reports are attached as Exhibit D (collectively, the "Inquiry Reports").

## II. INVESTIGATION COMMITTEE REVIEW PROCESS

### A. NSF Letter

On March 16, 2023, the University received an investigation referral letter from NSF, attached hereto as Exhibit E (the "NSF Letter"). The NSF Letter stated that NSF had concluded that there is sufficient evidence to proceed with an investigation into the research activities conducted for the Nature 2020 (CSH) Paper and PRL 2021 ($MnS_2$) Paper. According to the NSF Letter, NSF's concerns related to the PRL 2021 ($MnS_2$) Paper stemmed from email correspondence and other written materials from James Hamlin, PhD, Associate Professor, University of Florida.[17] NSF also flagged certain "Additional Considerations" for the University's and the Investigation Committee's review and response in the event that research misconduct is found as to any of the allegations; these considerations are addressed later in this report.

NSF charged that the University should "obtain and review all relevant documents and interview individuals, including any colleagues and others who may have knowledge of the data collection and analysis reported in [the Nature 2020 (CSH) Paper and the PRL 2021 ($MnS_2$) Paper]" and "secure pertinent research records," including all primary data, notebooks, manuscript drafts, computer files, and other relevant documents associated with the questioned research. NSF emphasized that "[n]othing in [its] letter should be construed as limiting the scope of [the University's] investigation" and that "[a]ny new evidence of allegations of misconduct should also be investigated." In addition, NSF noted that while each of the issues flagged in its letter must be addressed in the investigation, "misconduct involving other agencies' proposals and awards, as well as misconduct unrelated to Federal funding, can be relevant to the determination of state of mind and evidence of a pattern in an NSF-related case"—that is, when evaluating whether Respondent acted culpably (*i.e.*, recklessly, knowingly, or intentionally).

### B. Assembly of and Charge to Investigation Committee

Between late March 2023 and mid April 2023, Dr. Dewhurst corresponded with prospective members of the Investigation Committee to request their assistance in serving as members and to discuss any potential conflicts of interest relating to Respondent or others involved in the

[15] *Id.*
[16] *See* Inquiry Reviewer 5/Interviewee 2 Interview (Aug. 28, 2023) 30:6-31:6.
[17] *See* NSF Letter, Attachments 13-14.

research at issue.[18] Each Investigation Committee member confirmed their ability and willingness to serve and represented their willingness to carry out the investigation with objectivity. Each was forthcoming and transparent regarding past interactions with Respondent and others with involvement in the research at issue. The Investigation Committee formally convened and held its first meeting on May 16, 2023.

The Investigation Committee also is aware that around September 2023, well into the investigation proceedings and just after Respondent learned that certain of his co-authors would be requesting retraction of the Nature 2023 (LuH) Paper, Respondent for the first time raised certain specific concerns regarding the Investigation Committee's composition and certain alleged conflicts of interest of its members. Each Investigation Committee member separately discussed Respondent's concerns with the University, and based on that review and discussion, the University determined that the Committee would not be reconstituted despite Respondent's request for the same.

### C. The University's Research Misconduct Policy

Under the University's Policy on Research Misconduct (attached hereto as Exhibit F, the "Policy"), the Investigation Committee, when conducting its fact-finding, may interview the complainant(s) and any other available persons the Committee reasonably believes could have information regarding any relevant aspect of the investigation, including witnesses identified by Respondent and persons with appropriate scientific expertise, and pursue significant issues and leads that are determined to be relevant, including evidence of additional instances of potential research misconduct.[19] The Policy further states that upon concluding its investigation, the Investigation Committee is to prepare a report that states whether the Investigation Committee has found, based on a preponderance of the evidence, that research misconduct was committed and the Investigation Committee's basis for its finding.[20] This report serves to meet this Policy requirement.

Under the Policy, "research misconduct" is defined as fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. "Fabrication" is defined as making up data or results and recording or reporting them. "Falsification" is defined as manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record. "Plagiarism" is defined as the appropriation of another person's ideas, processes, results, or words without giving appropriate credit. Honest error or difference of opinion does not constitute research misconduct.[21]

Under federal regulations, a finding of research misconduct requires that: "(1) There be a significant departure from accepted practices of the relevant research community; and (2) [t]he

[18] Prospective members were asked to review the *Conflict-of-Interests and Confidentiality Statement for NSF Panelists, available at* https://www.nsf.gov/pubs/forms/NSF%20Form%201230P,%20Conflicts-of-Interests%20and%20Confidentiality%20Statement%20for%20NSF%20Panelists.pdf.
[19] The Policy, at 2.
[20] *Id.* at 3.
[21] *Id.* at 1.

research misconduct be committed intentionally, or knowingly, or recklessly; and (3) [t]he allegation be proven by a preponderance of evidence."[22]

**D. Investigation Process**

The Investigation Committee was assisted by Stephen Dewhurst, PhD, Vice President for Research at the University, as staff to the Investigation Committee, and by attorneys from Ropes & Gray LLP ("Ropes & Gray"), who served as advisors to the Investigation Committee and to Dr. Dewhurst.

In accordance with the Policy, NSF requirements, and the Investigation Committee's requests, the University sequestered various research records relevant to the investigation proceedings, including, without limitation, electronic records (*e.g.*, Box folders, email accounts, computer hard drives) and physical notebooks. The University also placed a hold on the University-issued email, Box, and OneDrive accounts of Respondent and of certain now-former members of Respondent's laboratory, to ensure appropriate maintenance of potential evidence related to the investigation. Each individual whose accounts were held and were likely to undergo search received an email notifying him or her that the University may search those records as part of the investigation.[23] On behalf of the Investigation Committee, select University personnel and Ropes & Gray conducted a targeted review of select email accounts, including manual searches and searches through use of analytics-based software. A list of the documents and records sequestered, and individuals whose records were subject to the above hold, is included in Exhibit G.[24]

The Investigation Committee also sent to Respondent several written requests for documentation. The relevant correspondence between the Investigation Committee and Respondent is included in Exhibit H.

The Investigation Committee reviewed the Inquiry Reports, the Papers, as well as research records obtained from the above-noted sequestration procedures, records provided by Respondent, interviewees, and journals, and publicly available materials. Those materials that support the Investigation Committee's findings are cited throughout Section III (Findings) and are summarized at Exhibit I (Crosswalk of Papers/Submission and Associated Sources of Evidence). Between May and December 2023, the Investigation Committee met at least 50 times for investigation-related planning and deliberations, as well as report-writing.[25] During certain of those meetings, the Investigation Committee interviewed the following individuals via Zoom:

[22] 45 C.F.R. § 698.2(c).
[23] *See, e.g.*, Email from Stephen Dewhurst to Respondent (Aug. 9, 2023) (on file as 2023-08-09 Email Dewhurst to Dias_Re Email-Doc Review.pdf).
[24] During the Investigation Committee's review of email evidence, the Investigation Committee observed that Respondent used his personal Gmail account to communicate with laboratory members, collaborators, and journals.
[25] A detailed schedule of the Investigation Committee's meetings can be made available upon request.

| **Interviewee** | **Interview Date(s)** |
|---|---|
| Interviewee 1 | Sept. 5, 2023 |
| Interviewee 3 | July 20, 2023 |
| Interviewee 2 | Aug. 28, 2023 |
| Respondent | June 9, 2023<br>July 7, 2023<br>July 14, 2023 |
| Interviewee 4 | July 31, 2023<br>Aug. 16, 2023<br>Aug. 17, 2023 |
| Interviewee 5 | July 20, 2023 |
| Interviewee 6 | July 20, 2023<br>Aug.16, 2023 |
| Interviewee 7 | Oct. 2, 2023 |
| Interviewee 8 | July 20, 2023 |
| Interviewee 9 | July 31, 2023 |

Esquire Deposition Solutions generated transcripts of all interviews based on Zoom video recordings of the interviews. Transcripts were provided to the interviewees for their review, and both interviewees and Ropes & Gray revised the transcripts for clear errors.[26]

In addition to the interviews listed above, the Investigation Committee also specifically requested interviews with Respondent to be held in August 2023 and October 2023, but Respondent did not ultimately appear before the Investigation Committee as requested after July 2023.

- Regarding the August 2023 requested interview, Respondent told Dr. Dewhurst that, on the requested meeting date, Respondent would be in Chicago to work with Dr. Hemley and his students on "an important project, aiming to strengthen the support for our reddmatter discovery through enhanced replication efforts." Respondent offered additional dates in August, which the Investigation Committee was unable to accommodate, such that Dr. Dewhurst again asked Respondent to reconsider and take a few hours out of his Chicago trip to meet with the Investigation Committee via Zoom. Respondent declined to do so, noting that the experiments to be conducted in Chicago were of "great personal importance to

[26] Respondent was provided with written transcripts and interview recordings of each of his interviews. He did not provide any comments or proposed edits directly to his written transcripts.

[Respondent]" and that it was "crucial" for him and his collaborators to "push[] forward with [their] efforts" in superconductivity.[27]

- The Investigation Committee's request for an interview in October 2023 triggered many communications between Respondent and Dr. Dewhurst. To summarize, after requesting and receiving information about the interview process,[28] Respondent noted that he was unable to meet due to his wife's imminent delivery of their child.[29] Upon learning of the same, the Investigation Committee determined that Respondent need not attend another interview despite its request and Dr. Dewhurst communicated that decision to Respondent.[30] However, Respondent then replied to say that he was "deeply disappointed to learn that the committee is unwilling to accommodate [his] family medical/parental situation" and that "scheduling accommodations are not being made, making it impossible for [him] to meet with the committee."[31] Dr. Dewhurst replied to state that, if Respondent was then requesting a meeting with the Investigation Committee (rather than, as had occurred, the Investigation Committee inviting Respondent to sit for an interview), that Respondent should provide dates for the Investigation Committee's consideration.[32] Respondent, however, did not respond to propose any dates for the interview he had requested, and instead wrote to Dr. Dewhurst to state his various objections to the investigation process.[33]

In accordance with the Policy,[34] on December 22, 2023, a draft copy of this investigation report (including exhibits, documents, and evidence cited to in this report) and Respondent's three interview transcripts were made available to Respondent for his review. In response to Respondent's request, on December 26, 2023, video recordings of Respondent's three interviews also were made available to Respondent. Other interviewees' transcripts, as well as sequestered laboratory notebooks, were available for in-person viewing at the University.

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[27] Email from Respondent to Stephen Dewhurst (Jul. 31, 2023) (on file as 2023-07-31 Email Dias to Dewhurst_Re July Committee Interview.pdf):

> I apologize for the inconvenience, but I regret to inform you that I won't be able meet with the committee this Wednesday. I have already prearranged plans for the week, and unfortunately, they are of great importance to me. I will be leaving on Tuesday afternoon and returning on Friday evening. I have series of scheduled meetings and experiments that cannot be rescheduled.
>
> The field of superconductivity research is currently experiencing momentous interest both in start-up sector and academia due to new potential findings. Given our position, it is crucial for us to keep pushing forward with our efforts.

[28] *See* Letter from Respondent to Stephen Dewhurst (Oct. 14, 2023) (on file as 2023-10-14 Letter Dias to Dewhurst_Re October Committee Interview.pdf); Email from Stephen Dewhurst to Respondent (Oct. 16, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[29] *See* Email from Respondent to Stephen Dewhurst (Oct. 17, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[30] *See* Email from Stephen Dewhurst to Respondent (Oct. 20, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[31] *See* Email from Respondent to Stephen Dewhurst (Oct. 22, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[32] *See* Email from Stephen Dewhurst to Respondent (Oct. 25, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[33] *See* Letter from Respondent to Stephen Dewhurst (Oct. 28, 2023) (on file as 2023-10-28 Letter Dias to Dewhurst_Re October Committee Interview.pdf); Email from Stephen Dewhurst to Respondent (Nov. 5, 2023) (on file as 2023-10-16 to 2023-11-05 Emails between Dias and Dewhurst_Re October Committee Interview.pdf).
[34] The Policy, at 3.

The Policy provides Respondent 30 days to review the report and provide a response. Due to the 30th day falling on Sunday, Respondent was provided an extra day of review, until Monday, January 22, 2024. On January 16, 2024, Respondent requested a two-week extension, until February 5, 2024. In response, the University provided a one-week extension until Monday, January 29, 2024. As discussed at Section V, Respondent provided a partial response on January 30, 2024, addressing only half of the allegations reviewed in this report. As of the date of this report, Respondent has not provided any additional response to the University or the Investigation Committee regarding the remaining allegations. Respondent's response is attached hereto as Exhibit J.

**E. Summary of Investigation Committee Findings**

Under the Policy, the role of the Investigation Committee is to make a recommendation as to whether, based on a formal examination and evaluation of relevant facts, it is more likely than not that research misconduct has occurred in regard to Respondent's experimental research at issue.

The Investigation Committee has viewed and heard significant evidence, described below in detail, supporting its conclusion that the preponderance of the evidence supports a finding of research misconduct for each of the 15 allegations pertaining to the Papers and one allegation pertaining to the NSF Proposal. Specifically, the Investigation Committee finds that Respondent engaged in falsification, fabrication, and/or plagiarism of data, images, and text within each of the Papers and the NSF Proposal. The Investigation Committee's determination, as set forth below in regard to each allegation, is that the evidence indicates that there was a significant departure from accepted research practice; that the misconduct was committed with at least recklessness; and that it is more likely than not that research misconduct occurred. The Investigation Committee wishes to emphasize, particularly for Respondent's benefit, that the Investigation Committee's charge was not to examine whether the scientific theories underlying the allegations are correct, but rather whether these allegations meet the criteria for research misconduct set forth immediately above.

The Investigation Committee also examined certain additional considerations specifically flagged for its review in the NSF Letter. As discussed in greater detail below, the Investigation Committee finds that: (i) Respondent's actions are part of a pattern—starting from his work as a graduate student at Washington State University ("WSU"); (ii) Respondent's actions have had a significant impact on the research record, former and current University students, other researchers, and other institutions; and (iii) Respondent was unable to recall having completed any particular training in the ethical conduct of research.

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## III. FINDINGS

### A. Nature 2020 (CSH) Paper

#### 1. Fabrication and/or falsification of R(T) data (resistance as a function of temperature)

Context:

A key property of superconducting materials is to exhibit zero electrical resistance when cooled under a material-specific critical temperature ($T_c$). Many materials are superconducting at very low temperatures (below 10 K), but very few materials are found to be superconducting above 100 K because thermal agitation tends to destroy the weak interactions that enable superconductivity.

**Figure 1a** and **Extended Data Figures 4, 7b, and 7c** from the Nature 2020 (CSH) Paper report 13 resistance versus temperature curves obtained with CSH samples at various pressures in the megabar range (1 Mbar ~ 1 million atmospheres). Pressure values are associated with 12 of the curves but no pressure value is indicated for the curve in **Extended Data Figure 7b**. However, from the data provided by Respondent, it can be established that the curve in **Extended Data Figure 7b** represents a subset of the data at 258 GPa shown in **Figure 1a**. **Figure 2b** shows an additional four curves, measured in the presence of an applied magnetic field. Each of the 13 zero field curves exhibits a clear, abrupt drop (essentially to zero resistance) upon decreasing temperature. If these data are taken at face value as reported in the Nature 2020 (CSH) Paper, this ensemble of data provides strong evidence for the superconductivity of CSH under extreme pressure. In addition, the Nature 2020 (CSH) Paper shows a sudden change in electrical resistance at temperatures in excess of 273 K (freezing point of water, ~32 Fahrenheit) and reaching 288 K (~59 Fahrenheit or 15 Celsius), which is higher than previous reliable reports for superconductivity and constitutes the basis for the claim in the title of the Nature 2020 (CSH) Paper for “room temperature superconductivity.”

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Figures for Reference:

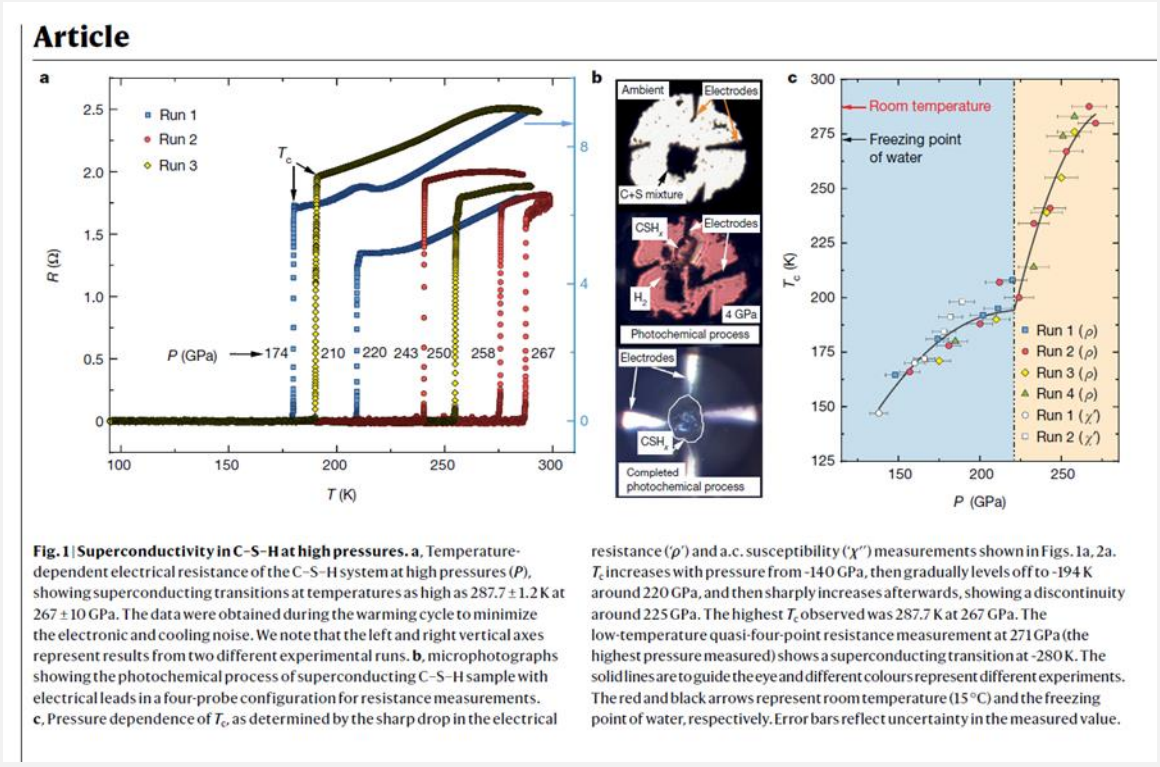


**Fig. 1 | Superconductivity in C–S–H at high pressures. a**, Temperature-dependent electrical resistance of the C–S–H system at high pressures (*P*), showing superconducting transitions at temperatures as high as 287.7 ± 1.2 K at 267 ± 10 GPa. The data were obtained during the warming cycle to minimize the electronic and cooling noise. We note that the left and right vertical axes represent results from two different experimental runs. **b**, microphotographs showing the photochemical process of superconducting C–S–H sample with electrical leads in a four-probe configuration for resistance measurements. **c**, Pressure dependence of $T_c$, as determined by the sharp drop in the electrical resistance (*ρ*) and a.c. susceptibility (*χ*″) measurements shown in Figs. 1a, 2a. $T_c$ increases with pressure from ~140 GPa, then gradually levels off to ~194 K around 220 GPa, and then sharply increases afterwards, showing a discontinuity around 225 GPa. The highest $T_c$ observed was 287.7 K at 267 GPa. The low-temperature quasi-four-point resistance measurement at 271 GPa (the highest pressure measured) shows a superconducting transition at ~280 K. The solid lines are to guide the eye and different colours represent different experiments. The red and black arrows represent room temperature (15 °C) and the freezing point of water, respectively. Error bars reflect uncertainty in the measured value.

Figures 1a, 1b, and 1c from the Nature 2020 (CSH) Paper.

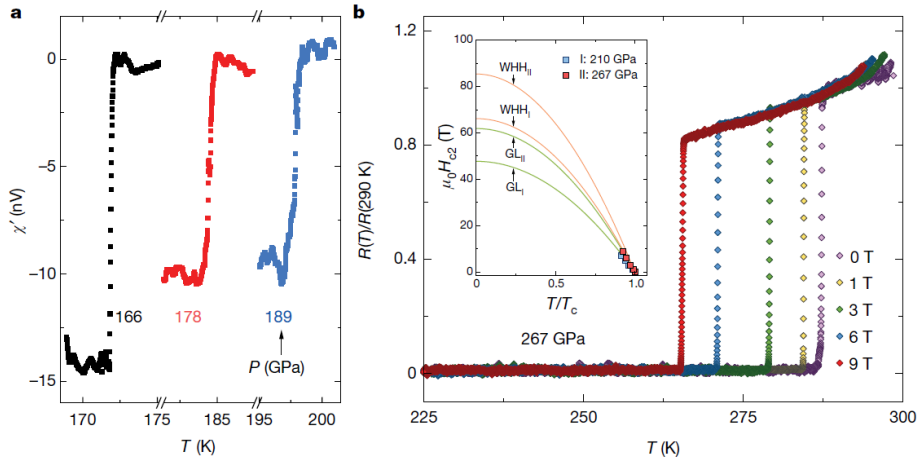


**Fig. 2 | Magnetic susceptibility and superconducting transition under an external magnetic field. a**, Real part of the a.c. susceptibility in nanovolts versus temperature for the C–S–H system at select pressures from run 2, showing substantial diamagnetic shielding of the superconducting transition for pressures of 160–190 GPa. The superconducting transition shifts rapidly under pressure to higher temperatures. $T_c$ is determined from the temperature at the transition midpoint. The background signal, determined from a non-superconducting C–S–H sample at 108 GPa, has been subtracted from the data. **b**, Low-temperature electrical resistance under magnetic fields of $H = 0$ T, 1 T, 3 T, 6 T and 9 T (increasing from right to left) at 267 GPa. Inset, upper critical field versus temperature at 210 GPa and 267 GPa, fitted with the GL and WHH models. At 210 GPa, the maximum field studied was 7 T.

Figure 2 from the Nature 2020 (CSH) Paper.

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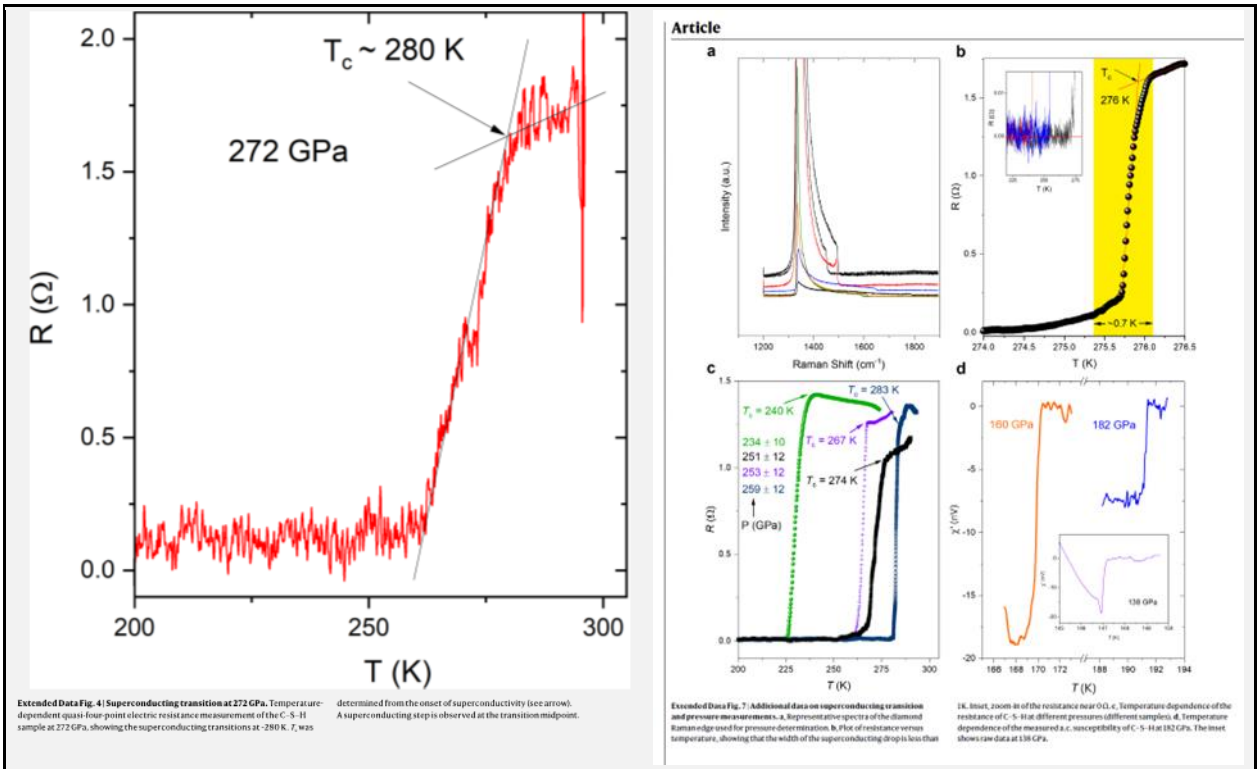


**Left:** Extended Data Figure 4 from the Nature 2020 (CSH) Paper. **Right:** Extended Data Figure 7 from the Nature 2020 (CSH) Paper.

Evidence:

- Interviewee 3,[35] Interviewee 8,[36] Interviewee 6,[37] and Interviewee 9[38] each stated independently, during separate interviews with the Investigation Committee, that resistance data for any of the published R(T) curves displayed in **Figure 1a**, **Figure 2b**, and **Extended Data Figures 4 and 7** from the Nature 2020 (CSH) Paper were not, to their knowledge and based on what Respondent had told them, measured in Respondent's laboratory at the University, but rather that those data were collected prior to Respondent's arrival at the University. These accounts directly contradict Respondent's statements to the Investigation Committee during interviews.[39]
- The capability to perform R(T) measurements at the University of Nevada, Las Vegas ("UNLV") did not exist at the time the article was prepared.[40] This contradicts Respondent's statements to the Investigation Committee that some of the data were measured at UNLV.[41]

[35] *See* Interviewee 3 Interview (Jul. 20, 2023) 20:7-9.
[36] *See* Interviewee 8 Interview (Jul. 20, 2023) 13:23-24, 14:4-14, and 15:8-23 ("I don't remember if it was from postdoc or grads, but [Respondent] said he had these [measurements] from previous work that he performed.").
[37] *See* Interviewee 6 Interview (Jul. 20, 2023) 16.
[38] *See* Interviewee 9 Interview (Jul. 31, 2023) 33.
[39] *See* R. Dias Interview (Jun. 9, 2023) 24, 26-27; and R. Dias Interview (Jul. 14, 2023) 81-85.
[40] *See* Interviewee 7 Interview (Oct. 2, 2023) 7:2–8:17.
[41] *See* R. Dias Interview (Jul. 14, 2023) 65-67, 70-71.

- Respondent failed to provide to the Investigation Committee a fulsome, raw (original) dataset for any of the published R(T) curves displayed in **Figure 1a**, **Figure 2b**, and **Extended Data Figures 4 and 7** from the Nature 2020 (CSH) Paper, despite repeated, specific requests from the Investigation Committee.[42] Instead, Respondent provided a series of .csv files (21 total),[43] each of which contain only two columns of data—a temperature series and a measured resistance series.
    - Electrical resistance measurements, similar to those at issue here, typically are obtained via a computer connected to the instruments to record the temperature (T) and measured voltage (V) across the sample at certain time intervals. When using a DC current source, the individual carrying out the experiment must have knowledge of the applied DC current (I) to determine the electrical resistance (R as R=V/I). Respondent indicated during his interview with, and in written response to,[44] the Investigation Committee that he used a LabVIEW and/or a Python code to interface with the instruments,[45] but was non-committal or self-contradictory when providing details regarding the measurement process.[46] Based on statements made by Interviewee 8, the Investigation Committee expects that the raw R(T) data should have at least four and up to seven columns of data (including time, temperature, voltage, and current)[47] and should span the full range of temperatures, from cryogenic (~10 K) to room temperature (300 K).[48] In addition, Respondent indicated that most of the measurements in question had been obtained with an AC current source and a lock-in amplifier.[49] In that case, it is customary practice, according to Interviewee 8,[50] to record the various outputs of a lock-in (amplitude and phase, in phase and quadrature components R, Θ, X, Y).[51] Such practice also is common in other research labs; for example, referee "Delta," assigned to post-publication review of the PRL 2021 ($MnS_2$) Paper, expected to see such a file structure in the data provided to *PRL* for the post-publication review of that publication.[52]
    - Respondent clearly stated during his interview with the Investigation Committee that the files provided to the Investigation Committee for its review were generated from Origin (a data analysis software tool), not from the laboratory recording tool (typically a

[42] *See* Exhibit H.
[43] 21 CSV files (on file collectively in the folder "21 .csv files") (Provided by Respondent to Investigation Committee). The file "EDFc_CSH.xlsx" contains four curves, and the file "EDF4_CSH.csv" contains one curve. Various files, named with the convention "xxGPa.csv," contain one curve each where "xx" is 148, 174, 210, 220, 243, 250, 258 and 267. Data for Figure 1a are in "Fig1a_CSH.xlsx." Data for Extended Figure 4 are in "EDF4_CSH.cvs." Data for Extended Figure 7a are in "EDFc_CSH.xlsx."
[44] *See* Lock-in Data Collection Pathway (on file as Lock-in data collection pathway.pdf) (Provided in response to the Investigation Committee's first request for materials, at Exhibit H).
[45] *See* R. Dias Interview (Jun. 9, 2023) 71-72.
[46] *See* R. Dias Interview (Jul. 14, 2023) 104-111.
[47] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19.
[48] *See* Interviewee 8 Interview (Jul. 20, 2023) 20:4-24:12.
[49] *See* R. Dias Interview (Jul. 14, 2023) 81:8-85:25.
[50] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19.
[51] *See, e.g.*, Model SR830 DSP Lock-In Amplifier User Manual, Revision 2.5 (Oct. 2011), 2-7, 2-8, *available at* https://www.thinksrs.com/mult/sr810830m.html.
[52] *See* Independent Report on Dr. Hamlin's Accusations of Data Copying in "Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator $MnS_2$" (PRL 127, 016401, 2021): Report Delta (on file as Report Delta.pdf).

LabVIEW program).[53] Respondent said he would provide the original files but failed to do so throughout this proceeding.

- Although Respondent stated that the measurements were collected during warming of the sample,[54] the temperature series in at least two instances of the R(T) data provided by Respondent (174 GPa and 220 GPa) have features localized near the superconducting transition that are not typical of a warming process and with similarities to the χ(T) data discussed in **Allegation A.3** (below). The proximity of these anomalous features to the superconducting transition appears to be systematic.[55]

- Respondent has provided contradictory information as to how the R(T) measurements were performed. The methods section of the Nature 2020 (CSH) Paper states, "[i]n all setups, the resistance in the two-probe configurations was measured using a Keithley DMM6500 multimeter, while the four-probe resistance was measured using a Keithley 2450 SMU and SIM921 a.c. resistance bridge." However, during interview, Respondent stated that a lock-in amplifier was used.[56]

- Prior to publication, Respondent provided R(T) data to co-authors only in the form of finished figures,[57] and not in the form of raw measurement data.[58]

- Dr. James Hamlin, Associate Professor of Physics at the University of Florida, raised public concerns regarding the Nature 2020 (CSH) Paper in a preprint published in arXiv. In this document, Dr Hamlin provided a means to extract the data from the various figures in the Nature 2020 (CSH) Paper by taking advantage of the underlying vector-graphics format. Dr. Hamlin analyzed extracted data from the 267 GPa R(T) curve and, based on that analysis, alleged data fabrication and/or falsification.[59] Using Dr. Hamlin's analysis tools (available online[60]), the Investigation Committee reproduced Dr. Hamlin's analysis using the open-source computer software Python. Dr. Hamlin later used the same software tools to support his analysis of the PRL 2021 ($MnS_2$) Paper; results from that analysis are available in the same online repository.[61]

- Dr. Dale Harshman, VP and CEO at Physikon Research Corporation, and Dr. Anthony Fiory, Bell Labs (retired), also raised public concerns regarding the Nature 2020 (CSH) Paper and published a related analysis in arXiv.[62] In Figure 9 of their analysis, Drs. Harshman and Fiory reveal an underlying statistical structure similar to the structures identified by Dr. Jorge Hirsch, Professor of Physics at the University of California San Diego, and Dr. Dirk van der Marel, Professor of Physics at the University of Geneva, in the arXiv preprint that describes

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[53] *See* R. Dias Interview (Jul. 14, 2023) 55:3-56:20.
[54] *See* R. Dias Interview (Jul. 14, 2023) 102-105.
[55] *See* Investigation Committee, *Temperature Anomalies* (Oct. 24, 2023) (on file as Temperature anomalies.pdf) (Investigation Committee's analysis of temperature anomalies).
[56] *See* R. Dias Interview (Jul. 14, 2023) 81:8-82:12.
[57] *See* R. Dias Interview (Jun. 9, 2023) 85:2-23.
[58] *See* Interviewee 7 Interview (Oct. 2, 2023) 12:23-13:4.
[59] James J. Hamlin, *Vector graphics extraction and analysis of electrical resistance data in Nature volume 586, pages 373-377 (2020)*, ARXIV (2022), https://arxiv.org/abs/2210.10766.
[60] James Hamlin, *GitHub*, https://github.com/jhamlin-ufl/vextract.
[61] *Id.*
[62] *See* Dale R. Harshman & Anthony T. Fiory, *Analysis of electrical resistance data from Snider et al., Nature 586, 373 (2020)*, ARXIV, Fig. 9 (2022) https://arxiv.org/abs/2212.06237.

Drs. Hirsch and van der Marel's concerns regarding the χ(T) data in the Nature 2020 (CSH) Paper.[63]

Findings/Reasoning:

Respondent has, to date, not provided for the Investigation Committee's review any raw data files that are relevant to this **Allegation A.1**. Respondent also provided data underlying the Nature 2020 (CSH) Paper to his co-authors only in the form of finished figures, and not in the form of raw measurement data. Respondent has provided contradictory or otherwise false information to the Investigation Committee as to *how* the data were measured and as to *where* the data were measured. Specifically, Respondent's assertions that the R(T) data were measured at the University are contradicted by independent statements of certain of his former students, who stated that (to their knowledge, based on what Respondent had told them) the data were not measured at the University, and Respondent's statements that some data were measured at UNLV are contradicted by evidence that no such capability existed at UNLV at that time. Therefore, the Investigation Committee concludes that the R(T) data most likely originated from Respondent, but not from measurements carried out through actual experiments at the University nor from experiments at UNLV.

Because raw data have not been made available to the public, to Respondent's co-authors, or to the Investigation Committee, the provenance of the data can only be inferred from analysis of the available data, as published. Dr. Hamlin's analysis revealed an anomalous structure in the 267 GPa R(T) data that is present in both **Figure 1a** and **Figure 2b** of the Nature 2020 (CSH) Paper,[64] and the structure of the resistance data series revealed in these data[65] is similar to the structure in the χ(T) data;[66] these observations indicate that the R(T) data were fabricated. In addition, an analysis by the Investigation Committee of what the Respondent stated were "raw data" also revealed anomalies in the first differences of the temperature data series of at least two instances (174 GPa and 220 GPa), indicating that the temperature data did not originate from an experimental measurement[67] and, instead and in the absence of any information from Respondent to the contrary, likely were fabricated by Respondent.

Conclusion:

Taken together, the above-noted evidence strongly indicates Respondent intentionally fabricated and/or falsified the R(T) data underlying **Figures 1a and 2b** and **Extended Data Figures 4, 7b, and 7c** of the Nature 2020 (CSH) Paper. This represents a significant departure from accepted practices within the research community.

[63] *See* discussion of the same at **Allegation A.3**.
[64] The data in Figure 1a correspond to zero applied magnetic field; the curve labeled "267 GPa" in Figure 1a also appears in Figure 2b on a truncated x-axis scale with the label "0 T" indicating zero applied field. Dr. Hamlin has shown that the underlying data corresponding to "267 GPa" in Fig. 1a and "0 T" in Figure 2b are identical.
[65] The 267 R(T) can be decomposed into a smooth component and a digitized component by unwrapping with a digitization increment of 0.0078. This is the same structure as was found in the χ(T) data.
[66] S*ee* **Allegation A.3** below.
[67] *See* Investigation Committee, *Temperature Anomalies* (Oct. 24, 2023) (on file as Temperature anomalies.pdf) (Investigation Committee's analysis of temperature anomalies).

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation A.1** constitutes research misconduct.

**2. Fabrication and/or falsification of Figure 1c, $T_c$(P) data (superconducting critical temperature as a function of pressure)**

Context:

It is expected from condensed matter theory that increasing external pressure can gradually modify the physical properties of a material and progressively enhance the interactions at the microscopic scale that are responsible for the emergence of superconductivity. Accordingly, studies of superconducting materials under high pressure usually document how the superconducting critical temperature ($T_c$) varies with increasing pressure.

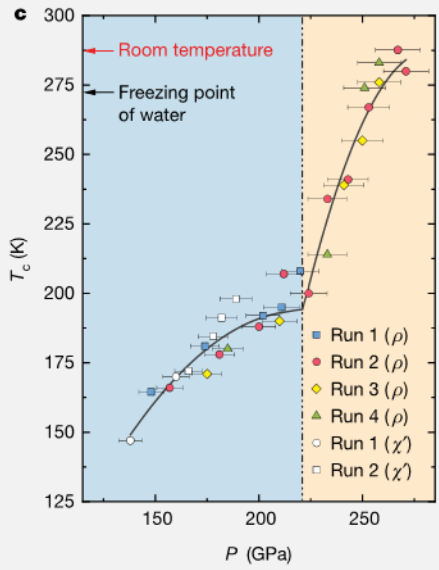
To obtain critical temperature ($T_c$) for a given material at a given pressure requires, first, collecting the temperature dependence of the physical quantity of interest (*e.g.*, R(T)), then—if a superconducting transition is observed—determining the value of the critical temperature ($T_c$) for the particular material at the particular pressure (usually with a well-defined and -documented methodology, *e.g.*, to identify inflection points in each R(T) curve).

Because materials are very incompressible in the megabar pressure range relevant here (*i.e.*, their density varies slowly with applied pressure), their properties are expected to change gradually with increasing pressure, except when a sudden rearrangement of the atomic or electronic structure occurs.

In the Nature 2020 (CSH) Paper, **Figure 1c** reports the evolution of the superconducting critical temperature ($T_c$) as a function of the pressure (P) that was obtained in four "Runs" of electrical resistance measurements ($\rho$ or R) and two "Runs" of magnetic susceptibility ($\chi$'). In total, 24 $T_c$(P) data points are labeled as originating from R(T) measurements, and six additional $T_c$(P) data points are labeled as originating from $\chi$'(T) measurements.

Reviewing the paper in isolation, the collection and presentation of the 30 data points in **Figure 1c** seems to provide a significant body of work that exhibits a clear, strong trend of gradually increasing critical temperature ($T_c$) with increasing pressure, with very little scatter. Therefore, on its face, **Figure 1c** appears to present compelling evidence to readers that CSH can indeed host superconductivity up to room temperature.

Figure for Reference:




**c**, Pressure dependence of $T_c$, as determined by the sharp drop in the electrical resistance ('$\rho$') and a.c. susceptibility ('$\chi''$') measurements shown in Figs. 1a, 2a. $T_c$ increases with pressure from ~140 GPa, then gradually levels off to ~194 K around 220 GPa, and then sharply increases afterwards, showing a discontinuity around 225 GPa. The highest $T_c$ observed was 287.7 K at 267 GPa. The low-temperature quasi-four-point resistance measurement at 271 GPa (the highest pressure measured) shows a superconducting transition at ~280 K. The solid lines are to guide the eye and different colours represent different experiments. The red and black arrows represent room temperature (15 °C) and the freezing point of water, respectively. Error bars reflect uncertainty in the measured value.

Figure 1c from the Nature 2020 (CSH) Paper.

Evidence:

- In his discussion with the Investigation Committee, Respondent assumed responsibility for assembling the data and preparing the figures and manuscript for the Nature 2020 (CSH) Paper,[68] and these statements of the Respondent were independently corroborated by the testimony of many of his co-authors.[69]
- Respondent indicated that "Run" labels in **Figure 1c** did not refer to the commonly accepted meaning of the word (*i.e.*, a series of measurements at various pressures, conducted with the same sample loading in the DAC),[70] but rather that "Runs" were groups of samples with similar composition. Respondent's interpretation is neither mentioned in the paper's

[68] *See, e.g.*, R. Dias Interview (Jun. 9, 2023) 86:2-6.
[69] *See* Interviewee 8 Interview (Jul. 20, 2023) 13:6-17, 32-33; Interviewee 3 Interview (Jul. 20, 2023) 11:8-15; Interviewee 6 Interview (Jul. 20, 2023) 16; Interviewee 7 Interview (Oct. 2, 2023) 12:9-13:20.
[70] *See, e.g.*, Supplementary Material in Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Xiaoyu Wang, Noah Meyers, Keith V. Lawler, Eva Zurek, Ashkan Salamat & Ranga P. Dias, *Synthesis of Yttrium Superhydride Superconductor with a Transition Temperature up to 262 K by Catalytic Hydrogenation at High Pressures*, PHYS. REV. LETT. 126, 117003 (Mar. 19, 2021), https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.126.117003; *see also* Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Xiaoyu Wang, Noah Meyers, Keith V. Lawler, Eva Zurek, Ashkan Salamat, & Ranga P. Dias, *Expression of Concern: Synthesis of Yttrium Superhydride Superconductor with a Transition Temperature up to 262 K by Catalytic Hydrogenation at High Pressures [Phys. Rev. Lett. 126, 117003 (2021)]*, PHYS. REV. LETT. 131, 239902 (Dec. 7, 2023), https://doi.org/10.1103/PhysRevLett.131.239902.

methods section nor in related follow-up arXiv documents,[71] and is contradicted by the statements of certain interviewees.[72]

- **Supplementary Table 4** for this article tabulates, in 6 columns and 47 rows, all measurement data in the study.[73] There are multiple discrepancies between **Supplementary Table 4** and **Figure 1c**. Detailed examination and comparison of **Supplementary Table 4** to **Figure 1c** reveals the following:
  - The two rows of "Run 12" at 148 GPa and 174 GPa in **Supplementary Table 4** match the lowest pressure points of "Run 1" in **Figure 1c** and the last three out of the four rows labeled "Run 13" (202, 211, and 220 GPa) in **Supplementary Table 4** match the remaining three points of "Run 1" in **Figure 1c**. The "Run 12" and "Run 13" entries use different diamond culet sizes and clearly are different "Runs" according to the commonly accepted meaning of the word "Run" in the context of diamond anvil cell research, yet $T_c$(P) data related to these experiments are indicated on **Figure 1c** as originating from the same "Run."
  - Similarly, the first row of "Run 13" (158 GPa) in **Supplementary Table 4** appears to match the 158 GPa point of "Run 2" in **Figure 1c**, while other points for "Run 2" in **Figure 1c** appear to correlate with entries under "Run 14" and "Run 15" in **Supplementary Table 4**.
  - **Figure 1c** has 24 $T_c$(P) data points derived from resistance measurements, while **Supplementary Table 4** lists 18 rows containing single $T_c$ values plus one row (last entry of "Run 15") that indicates a pressure range, 157 – 271 GPa and a $T_c$ range, 166 – 287 K, implying that this entry accounts for the six remaining $T_c$ points.
  - **Supplementary Table 4** shows that successful superconducting resistance observations were found in six runs (12, 13, 14, 15, 24, and 28); however, only four "Runs" associated with resistance-derived data are indicated in **Figure 1c.**
- In addition to the 12 R(T) datasets identified in **Allegation A.1**, Respondent provided a data file for one additional curve, at 148 GPa,[74] that was not included in the published figures. Thus, out of the 24 $T_c$(P) data points in **Figure 1c** labeled as originating from R(T) measurements, Respondent has provided datasets corresponding to only 13 $T_c$(P) data

[71] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017; Ranga P. Dias & Ashkan Salamat, *Reply to "Comment on Nature 586, 373 (2020) by E. Snider et al.*," ARXIV (2022), https://arxiv.org/abs/2201.11883.
[72] *See* Interviewee 8 Interview (Jul. 20, 2023) 15:25-17:18; Interviewee 5 Interview (Jul. 20, 2023) 28:10-29:17; Interviewee 6 Interview (Jul. 20, 2023) 21:15-22:12.
[73] *See* Supplementary Information in Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Mathew Debessai, Hiranya Vindana, Kevin Vencatasamy, Keith V. Lawler, Ashkan Salamat & Ranga P. Dias, *Room-temperature superconductivity in a carbonaceous sulfur hydride*, NATURE 586, 373 (2020), https://doi.org/10.1038/s41586-020-2801-z, *also available at* https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-020-2801-z/MediaObjects/41586_2020_2801_MOESM1_ESM.pdf.
[74] *See* 148GPa dataset from the 21 CSV files (on file as 148GPa.csv in the folder "21 .csv files").

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points[75] measured with zero magnetic field,[76] despite repeated, specific requests from the Investigation Committee.[77] The Investigation Committee was unable to locate data files underlying any of the remaining 11 $T_c$(P) data points.

- Of the data files provided by Respondent, none indicate the "Run" identifier associated with the curve; all files provided include only two data columns (temperature, resistance) and none start at temperatures lower than 80 K. Moreover, none of the provided files constitutes raw (original) data because they do not show the expected number of data columns.[78]
- Respondent stated during his third interview with the Investigation Committee that the missing curves had been measured at UNLV.[79] This contradicts Respondent's statements made during his initial interview with the Investigation Committee, during which Respondent implied that the data had been collected at the University by Respondent and his then-current team of students.[80]
- Based on interviews with former members of Respondent's laboratory and Interviewee 7, the Investigation Committee understands that UNLV students from Interviewee 7's laboratory went to the University to perform R(T) measurements on $MnS_2$ for the PRL 2021 ($MnS_2$) Paper in September 2019 because there was no capability for measuring R(T) at UNLV at the time.[81] Interviewee 7 corroborated that a capability to perform the R(T) measurements at UNLV ***did not exist*** at the time,[82] which also contradicts statements made by Respondent to the Investigation Committee.[83]

Findings/Reasoning:

The labeling of "Runs" in **Supplementary Table 4** clearly does not match the "Runs" in the legend annotated in **Figure 1c**. There are four runs indicated in **Figure 1c**, while there are six runs associated with resistance measurements in Table 4 of the supplementary material. **Supplementary Table 4** clearly shows that 18 or more data curves over six runs should exist to support the set of 24 $T_c$(P) data points plotted in **Figure 1c** that are based on resistance measurements. These inconsistencies indicate, at the least, reckless recordkeeping and preparation of **Figure 1c**. This is puzzling because **Figure 1c** is central to the article's claim.

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[75] *See* 21 CSV files (on file collectively in the folder "21 .csv files") (Provided by Respondent to Investigation Committee). The file "EDFc_CSH.xlsx" contains four curves, and the file "EDF4_CSH.csv" contains one curve. Various files, named with the convention "xxGPa.csv," contain one curve each where "xx" is 148, 174, 210, 220, 243, 250, 258 and 267. Data for Figure 1a are in "Fig1a_CSH.xlsx." Data for Extended Figure 4 are in "EDF4_CSH.cvs." Data for Extended Figure 7a are in "EDFc_CSH.xlsx."

[76] Of the 21 CSV files, the data files named "1T_CSH.csv," "3T_CSH.csv," "6T_CSH.csv," and "9T_CSH.csv" were collected with an applied magnetic field and do not pertain to Figure 1c.

[77] *See* Exhibit H.

[78] *See* "Evidence" Section at **Allegation A.1**.

[79] *See* R. Dias Interview (Jul. 14, 2023) 66:15-21.

[80] *See* R. Dias Interview (Jun. 9, 2023) 24:9-14, 55:21-25, 65-66, 75:14-18, 84:22-84:24.

[81] *See* Interviewee 8 Interview (Jul. 20, 2023) 44:7-21; Interviewee 3 Interview (Jul. 20, 2023) 26:18-25; Interviewee 5 Interview (Jul. 20, 2023) 16:3-12; Interviewee 7 Interview (Oct. 2, 2023) 9:11-21.

[82] *See* Interviewee 7 Interview (Oct. 2, 2023) 7:2-8:17.

[83] *See* R. Dias Interview (Jul. 14, 2023) 65-67, 70-71.

Respondent provided 13 R(T) datasets to the Investigation Committee, from which 13 of the $T_c$(P) points shown in **Figure 1c** could be inferred by the Investigation Committee. However, as explained elsewhere in this report,[84] the Investigation Committee found that those 13 datasets were more likely than not to have been fabricated and/or falsified.

As for the remaining 11 $T_c$(P) points shown in **Figure 1c**, Respondent has not, to date, provided any credible indication for the existence of the 11 additional R(T) datasets from which those data points may be inferred.

Respondent stated during his third interview with the Investigation Committee that the 11 data points in **Figure 1c** with missing underlying data were extracted from measurements carried out at UNLV, which contradicts (i) Respondent's statements during his prior interview with the Investigation Committee and (ii) the fact that, as reported to the Investigation Committee by Interviewee 7 and several former members of Respondent's lab, no such measurement capability existed at UNLV at the time.

Conclusion:

These multiple inconsistencies lead the Investigation Committee to conclude that ***all*** $T_c$(P) data points allegedly derived from R(T) data in **Figure 1c** likely were fabricated and/or falsified. The inconsistency between the interview responses of Respondent (on the one hand) and of his co-authors (on the other hand) regarding the origin of the $T_c$(P) data, Respondent's inability to produce relevant data for the Investigation Committee's review, and the internal inconsistences between **Figure 1c** and **Supplementary Table 4** all strongly indicate that Respondent intentionally fabricated and/or falsified these data. This represents a significant departure from accepted practices within the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation A.2** constitutes research misconduct.

### 3. Fabrication and/or falsification of χ(T) data (magnetic susceptibility as a function of temperature)

Context:

Superconducting materials exhibit strong diamagnetism. Demonstrating that a material abruptly begins to repel magnetic fields—*e.g.*, by observing a sudden drop of the magnetic susceptibility to negative values when cooled below a critical temperature—is convincing evidence towards supporting a superconductivity claim. Such a claim for the observation of superconductivity becomes particularly strong if it combines the observation of a drop to zero electrical resistance and a sudden drop of the magnetic susceptibility to negative values at similar temperatures.

The magnetic susceptibility experiments reported in the Nature 2020 (CSH) Paper are extremely difficult in terms of technical execution (because reaching megabar pressure requires using a small sample, ~ micrometer sized) and, if these reported experiments are taken at face value, would attest to extraordinary technical skill of the authors and reinforce the case for

[84] *See* **Allegations A.1 and A.3**.

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superconductivity in CSH and for the rapid increase in critical temperature ($T_c$) with increasing pressure, which, if valid, makes the claim for room-temperature superconductivity more credible.

Figures for Reference:

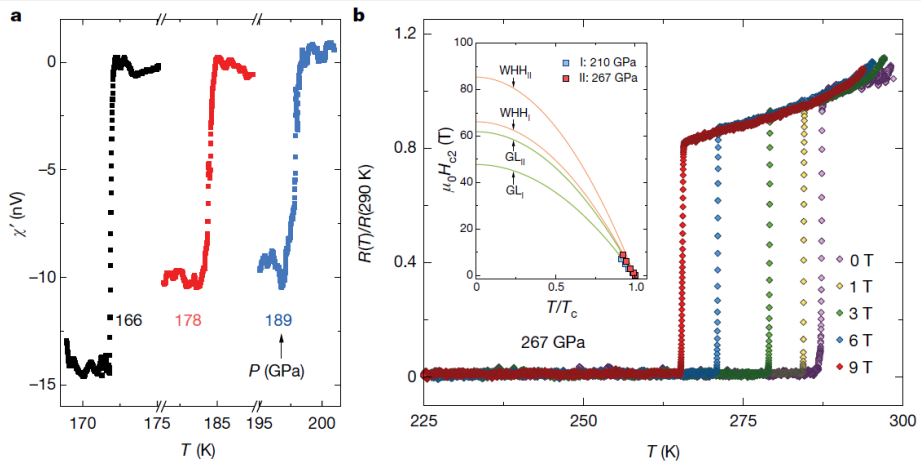


**Fig. 2 | Magnetic susceptibility and superconducting transition under an external magnetic field. a**, Real part of the a.c. susceptibility in nanovolts versus temperature for the C–S–H system at select pressures from run 2, showing substantial diamagnetic shielding of the superconducting transition for pressures of 160–190 GPa. The superconducting transition shifts rapidly under pressure to higher temperatures. $T_c$ is determined from the temperature at the transition midpoint. The background signal, determined from a non-superconducting C–S–H sample at 108 GPa, has been subtracted from the data. **b**, Low-temperature electrical resistance under magnetic fields of $H = 0$ T, 1 T, 3 T, 6 T and 9 T (increasing from right to left) at 267 GPa. Inset, upper critical field versus temperature at 210 GPa and 267 GPa, fitted with the GL and WHH models. At 210 GPa, the maximum field studied was 7 T.

Figure 2a from the Nature 2020 (CSH) Paper.

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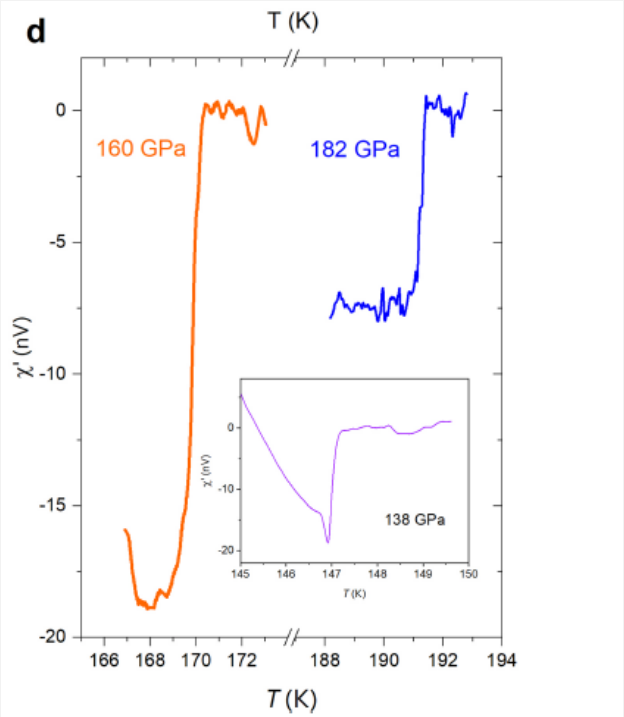


1 K. Inset, zoom-in of the resistance near 0 Ω. **c**, Temperature dependence of the resistance of C–S–H at different pressures (different samples). **d**, Temperature dependence of the measured a.c. susceptibility of C–S–H at 182 GPa. The inset shows raw data at 138 GPa.

Extended Data Figure 7d from the Nature 2020 (CSH) Paper.

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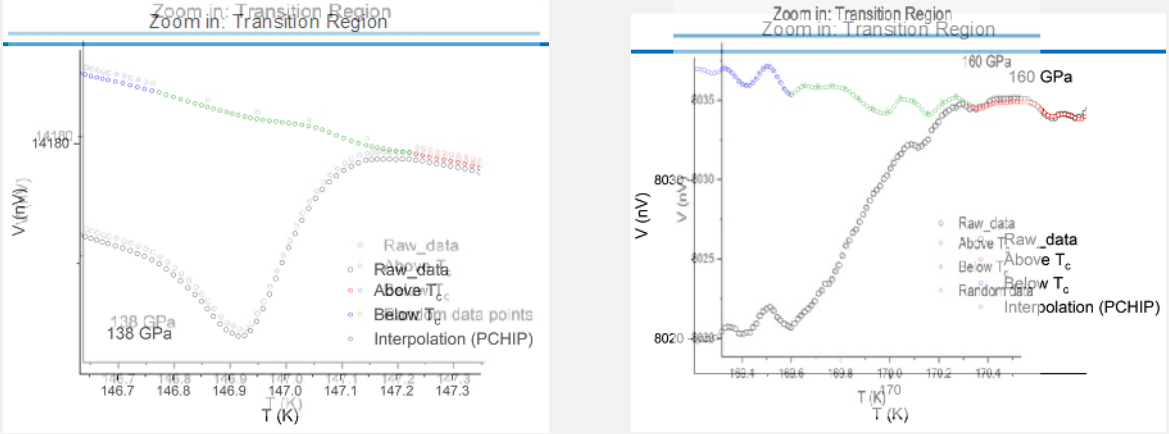


**Figure CSH_1: Analysis by the Investigation Committee: Left:** Overlay of slides 6 and 8 of Respondent's slide set describing the construction of UDB_1 (defined in the text body, below) in the superconducting transition region for the 138 GPa example. Close examination of slide 8 shows 41 data points (green) which are sampled by 6 equally spaced spline knot points (green) spanning 8 data points each.[85] **Right:** Overlay of slides 15 and 17 of Respondent's slide set describing the construction of UDB_1 in the superconducting transition region for the 160 GPa example. Close examination of slide 17 shows 53 data points (open green circles) which are sampled by 14 equally spaced spline knot points (solid green circles) spanning 4 data points each.

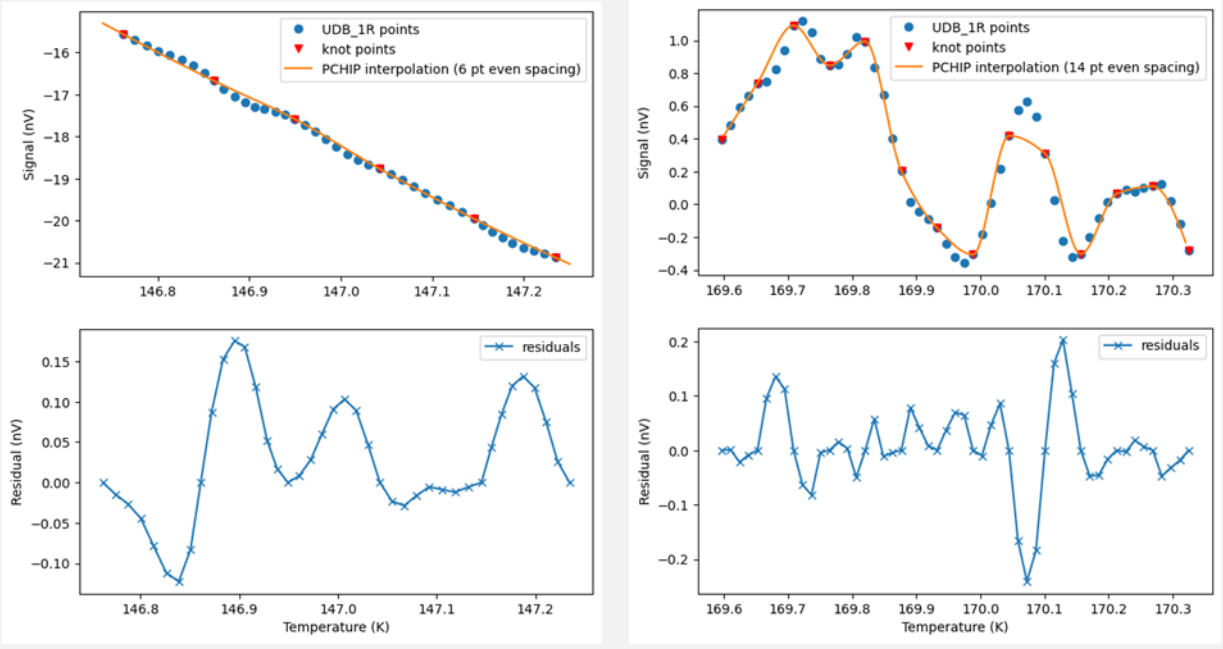


**Figure CSH_2: Left:** Analysis by the Investigation Committee: PCHIP (defined in the text body, below) interpolation using the six equally spaced knot points shown in Figure CSH_1, above, corresponding to the points in the 138 GPa example on slide 8.[86] **Right:** PCHIP interpolation using the 14 equally spaced knot points shown in Figure CSH_1, above, corresponding to the points shown in the 160 GPa example on slide 17. ***In both cases, the PCHIP interpolation does not pass through the UDB_1R*** (defined in the text body, below) ***data, which reveals that the UDB_1R data could not have been obtained by PCHIP interpolation of the knot points plotted on Slides 6 and 15.***

[85] *See* Inquiry Report #2 in Exhibit D, (also on file as Attachment 03 – Inquiry Report.pdf starting at page 20, "Exhibit B: Slides by Dias and Salamat describing the user-defined background procedure"). Slide 8 is labeled "Zoom in: Transition Region."
[86] *Id.*

Evidence:

- During interviews with the Investigation Committee, Interviewee 3,[87] Interviewee 6,[88] and Interviewee 9[89] each stated that the $\chi$(T) data were, to their knowledge, collected prior to Respondent's arrival at the University and were not measured at the University. However, this contradicts Respondent's statements to the Investigation Committee, that the measurements were conducted at the University, with his students.[90]
- Prior to publication, Respondent provided the $\chi$(T) data to co-authors only in the form of finished figures, and not in the form of raw (original) measurements.[91]
- Respondent failed to provide to the Investigation Committee a fulsome, raw (original) dataset for published $\chi$(T) curves in **Figure 2a** and **Extended Data Figure 7d**. Instead, Respondent provided warming curves, with only two data columns spanning a very narrow temperature range. However, based on statements from Interviewee 8, the Investigation Committee expects that raw $\chi$(T) data should have at least four and up to seven data columns[92] and should span the full range of temperatures from cryogenic (~10 K) to room temperature (300 K). Respondent told the Investigation Committee that the files provided by Respondent to the Investigation Committee were generated from Origin analysis software, not from the laboratory recording tools (such as LabVIEW).[93] Respondent verbally agreed to provide such original files to the Investigation Committee but failed to do so during this proceeding.
- For more than one year after publication of the Nature 2020 (CSH) Paper, Respondent failed to respond to requests from interested readers to provide the raw $\chi$(T) data. On November 29, 2021, more than 13 months after publication (October 14, 2020), Respondent and Interviewee 7 made tabulated versions of the data publicly available—specifically, a dataset labeled as "measured data" and a dataset labeled as "published data" for each of the published $\chi$(T) curves.[94] It should be possible to derive the "published data" from the "measured data" by a suitable background subtraction. Plots of the published data match the curves plotted in **Figure 2a** and **Extended Data Figure 7d**, and also the curve in the inset in **Extended Data Figure 7d**.[95]

[87] *See* Interviewee 3 Interview (Jul. 20, 2023) 11:17-23.
[88] *See* Interviewee 6 Interview (Jul. 20, 2023) 16:7-25.
[89] *See* Interviewee 9 Interview (Jul. 31, 2023) 33:4-25.
[90] *See* R. Dias Interview (Jun. 9, 2023) 27:12-28:14, 29:18-22, and 76:15-25.
[91] *See, e.g.*, Interviewee 7 Interview (Oct. 2, 2023) 12:23-13:4.
[92] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19; Interviewee 7 Interview (Oct. 2, 2023) 29:16-30:6.
[93] *See* R. Dias Interview (Jul. 14, 2023) 55:17-56:20.
[94] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017.
[95] In this report, the quotation marks are retained when referring to the "measured data" because the Investigation Committee's findings, described below, indicate that these data were not produced by a measurement (*i.e.*, they were not measured).

- Analysis by Drs. van der Marel and Hirsch of the published, tabulated χ(T) data identified a series of unusual features indicative of data fabrication.[96] The Investigation Committee examined Drs. van der Marel's and Hirsch's respective analyses in detail and were able to reproduce the main elements of the analysis, thereby confirming the validity of the findings of Drs. van der Marel and Hirsch. Drs. van der Marel and Hirsch each identified the presence of a cubic spline,[97] which was confirmed and corroborated by the Investigation Committee.[98] The Investigation Committee confirmed the unusual statistical structure in the data, as noted by Drs. van der Marel and Hirsch, that originates from a quantized component in the signal; this component is not present in the "measured data" and is not characteristic of the instrumentation.[99] The Investigation Committee also observed a strong correlation between the inferred background function and the "measured data," and a weak correlation between the published data and the background function.[100] The analysis of Drs. van der Marel and Hirsch concludes that data fabrication (referred to as "Protocol 3" in their analysis) is the only reasonable way to understand the unusual features in the data as presented in the manuscript. No flaws were detected by the Investigation Committee in the analysis of Drs. van der Marel and Hirsch, and the Investigation Committee agrees with the conclusions of Drs. van der Marel and Hirsch.
- While the caption of **Figure 2a** of the Nature 2020 (CSH) Paper stated explicitly that "[t]he background signal, determined from a non-superconducting C–S–H sample at 108 GPa, has been subtracted from the data," Respondent later described[101] an unusual expression to estimate the measurement background, termed user defined background ("UDB") version 1 ("UDB_1"); the prescription for computing UDB_1 depends on the measured data and additional information.[102]
    - Interviewee 7 indicated that Respondent created the UDB_1 construction.[103]

[96] Dirk van der Marel & Jorge E. Hirsch, *Extended Comment on Nature 586, 373 (2020) by E. Snider et al*, ARXIV (2022), https://arxiv.org/abs/2201.07686; Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001 (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012.
[97] Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001, Figs. 4-5, Table 1 (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012.
[98] *See* 160GPa-analysis-rev5 § 7 (Nov. 28, 2023) (on file as 160GPa-analysis-rev5.pdf) (Investigation Committee's 160 GPa analysis).
[99] *See* Dirk van der Marel & Jorge E. Hirsch, *Extended Comment on Nature 586, 373 (2020) by E. Snider et al*, ARXIV Fig. 11 (2022), https://arxiv.org/abs/2201.07686; Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001, Fig. 11 (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012; *see also* 160GPa-analysis-rev5 §§ 5, 6, and 9 (Nov. 28, 2023) (on file as 160GPa-analysis-rev5.pdf) (Investigation Committee's 160 GPa analysis).
[100] Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001, Figs. 19-20 (2023) , https://www.worldscientific.com/doi/10.1142/S0217979223750012.
[101] *See* Inquiry Report #2 in Exhibit D, (also on file as Attachment 03 – Inquiry Report.pdf starting at page 20, "Exhibit B: Slides by Dias and Salamat describing the user-defined background procedure").
[102] *Id*.
[103] *See* Interviewee 7 Interview (Oct. 2, 2023) 19:1-20:10.

- Respondent confirmed during interviews with the Investigation Committee that applying the prescription for computing UDB_1 should produce the same results as would be obtained by subtracting the published data from the "measured data."[104] In the description below, a modified term, "UDB_1R," is used to refer to this way of reconstructing UDB_1 from the data provided by Respondent.

- The prescription for constructing UDB_1 is elaborate and different from the background subtraction described in the Nature 2020 (CSH) Paper. It also is different from standard methods used by other researchers.[105] Respondent stated that UDB_1 was constructed to mimic the "measured data."[106] Respondent provided no credible explanation to justify the complexity of the construction.

- With complete information, and if one assumes that the UDB_1 prescription is correct, it should be possible to reproduce UDB_1R from the prescription for UDB_1. However, the prescription for computing UDB_1 cannot reproduce UDB_1R due to ***missing information***. The missing information includes, for each curve: (i) the "noise" values for the upper and lower temperature branches;[107] and (ii) the set of "random data" points spanning the superconducting transition region[108] (according to the prescription provided by Respondent, these are used to define a piecewise cubic Hermite interpolating polynomial ["PCHIP"] in this region).[109] Respondent was asked to provide this information but, to date, has not provided it.

- Within the superconducting region, the only missing information needed to construct UDB_1 is a list of the knot points used to construct the PCHIP interpolation. Respondent was unable to supply such knot points despite detailed probing during interview with the Investigation Committee.[110] The Investigation Committee attempted to reproduce UDB_1R within the superconducting transition region for the 138 GPa and 160 GPa datasets using PCHIP interpolation and the set of points indicated in the slide set provided by Respondent and Interviewee 7.[111] The Investigation Committee found that UDB_1R is not consistent with PCHIP interpolation within the superconducting transition region.[112] Therefore, the Investigation Committee concludes that it is highly

[104] *See* R. Dias Interview (Jul. 7, 2023) 59:25-60:25.
[105] A typical background subtraction method is to fit a low-order polynomial (typically up to third order) to segments of the data away from the feature of interest and then to subtract the polynomial fit so that a portion of the background-subtracted data near the feature of interest resides close to zero along the y-axis. The signal magnitude can then be estimated by the magnitude by which the background-subtracted data departs from the y-axis in the region where the effect (superconductivity) is manifested. For superconductivity, the departure typically is in the negative direction.
[106] *See* R. Dias Interview (Jul. 7, 2023) 36:25-37:21.
[107] Inquiry Report #2 in Exhibit D, 23-24, 32-33, 53-61 (also on file as Attachment 03 – Inquiry Report.pdf starting at page 20, "Exhibit B: Slides by Dias and Salamat describing the user-defined background procedure").
[108] *Id*. at 25, 26, 34-35.
[109] *Id*. at 27-28, 36-37.
[110] *See* R. Dias Interview (Jul. 7, 2023) 47-52.
[111] *See* Figures CSH_1 and CSH_2, above; *see also* Inquiry Report #2 in Exhibit D, 26, 28, 35, 37 (also on file as Attachment 03 – Inquiry Report.pdf starting at page 20 "Exhibit B: Slides by Dias and Salamat describing the user-defined background procedure").
[112] *See* Figures CSH_1 and CSH_2, above.

improbable that either UDB_1 or UDB_1R was produced using PCHIP interpolation in the superconducting transition region.[113]

- Examination of the statistical distribution of second differences ($\chi_{i+1} - 2\chi_i + \chi_{i-1}$) of the published data in the superconducting transition region shows that it has a unique pattern that is not consistent with the "random data" prescription for defining UDB_1 in the superconducting gap region. The most probable explanation for understanding the relationship between the "measured data" and UDB_1R is that the "measured data" were ***computed*** by adding UDB_1R to the published data.[114]

Findings/Reasoning:[115]

The absence of any record of raw data and the presence of a cubic spline in the 160 GPa dataset indicates that the published data reported in the Nature 2020 (CSH) Paper result from data fabrication; cubic splines are smooth mathematical constructions, free of noise, and do not result from experimental measurement. The quantized component of the data results in an unusual statistical structure (discrete binning structure) of histograms of the second differences (or second derivatives), as noted by Drs. van der Marel and Hirsch regarding the published data. This also is strong evidence of data fabrication because the expected statistical distributions should show a Gaussian shape, or normal distribution, commensurate with the instrument noise. Strangely, the "measured data" ***do show*** the expected Gaussian distributions and they ***do not show*** the quantization. The puzzling nature of these features also was noted by Interviewee 1.[116]

To elaborate on these points in the context of the full dataset: the unusual features of the 160 GPa dataset uncovered by Drs. van der Marel and Hirsch (*i.e.*, a ***smooth, noise-free component*** and a ***digitized component***) are common to all the $\chi$(T) data reported in the Nature 2020 (CSH) Paper. This is made evident by examining the plots of the first differences ($\chi_i - \chi_{i-1}$) and the second differences ($\chi_{i+1} - 2\chi_i + \chi_{i-1}$) shown in Figures 8, 9, and 10 of their article.[117] Patterns of ***smooth variation*** with increasing temperature clearly are evident in the first and second differences plots at the four lowest pressures (138, 160, 166, and 178 GPa); these patterns are less evident, but still present, at the two highest pressures (182 and 189 GPa). Patterns of ***digitization*** also are evident in all the data. When the second differences are plotted as

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[113] *See* 160GPa-analysis-rev5 § 8 (Nov. 28, 2023) (on file as 160GPa-analysis-rev5.pdf) (Investigation Committee's 160 GPa analysis); 138GPa-analysis-rev2 § 6 (Nov. 28, 2023) (on file as 138GPa-analysis-rev2.pdf) (Investigation Committee's 138 GPa analysis).

[114] *See* 160GPa-analysis-rev5 § 9 (Nov. 28, 2023) (on file as 160GPa-analysis-rev5.pdf) (Investigation Committee's 160 GPa analysis).

[115] Post-publication review of the Nature 2020 (CSH) Paper focused on the $\chi$(T) data and resulted in the paper's retraction in September 2022 because the reviewers and editors were unable to confirm the reliability of the data. The reasoning for that conclusion follows broadly similar lines to the Investigation Committee's findings and reasoning, as described below.

[116] *See* Interviewee 1 Interview (Sep. 5, 2023) 23-28; Interviewee 1, *Analysis of Magnetic Susceptibility Data of Carbonaceous Sulphur Hydride from Nature 2020 paper* (on file as Reanalysis of CHS MS Data.pdf) (Slides provided by Interviewee 1 to the Investigation Committee); Interviewee 1, *Additional Analysis: Analysis of Magnetic Susceptibility Data of Carbonaceous Sulphur Hydride from Nature 2020 paper* (on file as Addtional_Slides_Mag_Susc_data.pdf) (Slides provided by Interviewee 1 to the Investigation Committee).

[117] Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001, Figs. 8-10 (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012.

histograms at Figure 11 of their article,[118] the digitization levels are evident and produce the uniformly spaced "picket fence" structure of the histograms. Rapidly varying regions of the smooth component will tend to smear out individual pickets; this is seen in all cases. ***This structure is anomalous and not representative of real data***; real data is noisy and histograms of the second differences of real data typically show a continuous Gaussian-shaped distribution with width proportional to the noise level of the recording instrument.[119] Finally, the anomalies in the published data are concealed in the "measured data" because these ***do not show*** underlying smooth features with digitization and because second differences of these ***do show*** a Gaussian distribution.[120] ***These inconsistencies indicate that the digitization observed in the published data does not originate from the instrumentation***.

Respondent put forth an explanation in his 2022 response article published in arXiv,[121] which stated that the UDB_1 background subtraction method can account for the unusual features in the published data and for the removal of noise. However, the Investigation Committee finds that:

1. The UDB_1 prescription cannot account for the spline observed in the 160 GPa dataset (or smooth components in the other datasets);
2. The UDB_1 prescription cannot account for the quantized component in the published data;
3. The UDB_1 prescription cannot account for the high degree of correlation between the measured data and UDB_1R in the superconducting transition region;
4. UDB_1R cannot be obtained by the prescription provided by Respondent because of incomplete information (missing "random data" and missing "noise" function); and
5. The inferred UDB_1R values in the superconducting transition region are not consistent with PCHIP interpolation.

Accordingly, the Investigation Committee finds that this evidence indicates that the UDB_1 prescription represents data falsification.

Taking this finding and the timeline into account, the Committee has determined that, by a preponderance of the evidence, the relationships between the published data, the "measured data," UDB_1, and UDB_1R are explained as follows: the published data were fabricated. Nearly 14 months after publication of the Nature 2020 (CSH) Paper, the "measured data" were presented. The "measured data" were computed by adding a noisy signal (UDB_1R) to the published data (second layer of fabrication). The elaborate prescription for UDB_1 was then created to provide a veneer of plausibility, by focusing critics' attention on background subtraction methods. UDB_1, as prescribed, was never used to perform background subtraction (falsification).

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[118] *Id*. at Fig. 11.

[119] Digitization effects may appear if the measurement is performed with a digital instrument with digitization levels comparable to the magnitude of the signal. In this case instrumental digitization should produce a clean "picket fence" structure with spacings matching the digitization increment (no smearing of individual pickets) for all histograms (first differences and all higher order differences); such is not the case for the $\chi$(T) data.

[120] Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001, Figs. 12-13 (lower frames) (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012.

[121] Ranga P. Dias & Ashkan Salamat, *Reply to "Comment on Nature 586, 373 (2020) by E. Snider et al.,"* ARXIV 4, 8 (2022), https://arxiv.org/abs/2201.11883.

Conclusion:

These findings indicate at least two instances of fabrication and at least one instance of falsification for each of the six χ(T) curves reported in the Nature 2020 (CSH) Paper: (1) fabrication of the initial χ(T) published data as evidenced by the smooth and quantized components leading to unusual statistical distributions; (2) fabrication of the "measured data" from the published data by adding a noisy component (UDB_1R) and publishing such data in the 2021 arXiv article;[122] and (3) manufacturing an incomplete (therefore, irreproducible) prescription for generating the background subtraction, UDB_1, that was never used (falsification).[123]

This sequence of events can only come about through intentional action and represents a significant departure from accepted practices within the research community. Therefore, the Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation A.3** constitutes research misconduct.

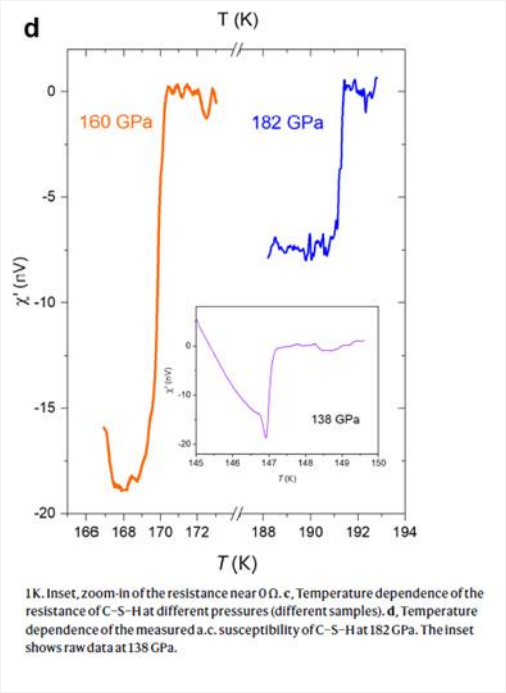
### 4. Falsification of 138 GPa inset in Extended Data Figure 7d, "raw" χ(T) data (magnetic susceptibility as a function of temperature)

Context:

The magnetic susceptibility experiments reported in the Nature 2020 (CSH) paper are, from a technical standpoint, extremely difficult to perform and thereby imply—if taken at face value—extraordinary technical skills of the authors. The signature for the superconducting transition represents only a minuscule fraction of the raw measured voltage; accordingly, it is customary to publish background subtracted traces that reveal the small drop in magnetic susceptibility towards negative values that is expected to occur upon cooling in a field cooling condition, as evidence of the Meissner effect (a unique signature of superconducting materials). However, it also is customary in the physical sciences community to publish the corresponding unprocessed, raw data to document that the expected signature also is noticeable in the raw data and to demonstrate the typical signal-to-background ratio.

[122] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017.
[123] Ranga P. Dias & Ashkan Salamat, *Reply to "Comment on Nature 586, 373 (2020) by E. Snider et al.,"* ARXIV (2022), https://arxiv.org/abs/2201.11883.

Figure for Reference:




1K. Inset, zoom-in of the resistance near 0 Ω. c, Temperature dependence of the resistance of C–S–H at different pressures (different samples). d, Temperature dependence of the measured a.c. susceptibility of C–S–H at 182 GPa. The inset shows raw data at 138 GPa.

Extended Data Figure 7d from the Nature 2023 (CSH) Paper

Evidence:

- The main panel of **Extended Data Figure 7d** shows curves labeled as "160 GPa" and "182 GPa" plotted on a graph with axes labeled χ'(nV) and T(K), with characteristics that indicate a background had been subtracted.
- The inset of **Extended Data Figure 7d** shows a plot of a similar curve with axes labeled χ'(nV) and T(K), and the caption states: "The inset shows raw data at 138 GPa."
- The background-subtracted data at 138 GPa was not included in the published manuscript, so the reader could not evaluate the background subtraction procedure or estimate the typical signal-to-background ratio.
- Several public comments were posted by Dr. Hirsch,[124] in which Dr. Hirsch discusses in detail the "raw" data shown in the inset of **Extended Data Figure 7d** and compares it to similar raw data for europium (Eu) under pressure. In his comments, Dr. Hirsch expresses serious doubts that such supposedly raw data could represent the true physical behavior of a material, given the large amplitude and rapid changes in susceptibility over a very narrow temperature range (~2 K) near 150 K. In a 2021 arXiv preprint co-authored by Respondent and Interviewee 7 in response to Dr. Hirsch's criticism, Respondent and Interviewee 7 do not specifically discuss the fact that the "raw" data at 138 GPa had been background-

[124] Jorge E. Hirsch, *On the ac magnetic susceptibility of a room temperature superconductor: anatomy of a probable scientific fraud*, ARXIV (2021), https://doi.org/10.48550/arXiv.2110.12854; Jorge E. Hirsch, *On the ac magnetic susceptibility of a room temperature superconductor: anatomy of a probable scientific fraud*, PHYSICA C: SUPERCONDUCTIVITY AND ITS APPLICATIONS 613, 1354228 (2023), https://doi.org/10.1016/j.physc.2023.1354228.

subtracted.[125]

- As discussed in **Allegation A.3**, the caption to **Figure 2a** of the Nature 2020 (CSH) Paper expressly states that "[t]he background signal, determined from a non-superconducting C–S–H sample at 108 GPa, has been subtracted from the data." This description is later contradicted by a different method for performing background subtraction (next point below).
- A slide deck prepared by Respondent and Interviewee 7, describing UDB_1 (the background subtraction prescription described at **Allegation A.3**, above), begins with the 138 GPa data and shows a different curve, supposedly representing the raw data.[126] After the UDB_1 correction is applied, slide 10 of the slide deck shows (under the heading "Published Figure") the identical 138 GPa data that appears in the inset of **Extended Data Figure 7d**. The same curves also are shown in Figure 7 of Respondent's explanation published in the above-noted 2021 arXiv article.[127]
- The raw data in **Extended Data Figure 7d** of the Nature 2020 (CSH) Paper are not the same as the raw data in the above-noted slide deck created by Respondent and Interviewee 7.
- These inconsistencies were noted by Drs. Hirsch and van der Marel in Appendix A of a 2022 publication.[128]
- Prior to publication of the Nature 2020 (CSH) Paper, Respondent was a lead author on three publications that explicitly referred to raw data,[129] indicating that he is aware of the distinction between raw data and processed or background-subtracted data.
- When the Investigation Committee asked about this issue, Respondent provided evasive answers.[130]

Findings/Reasoning:

Representation of a single dataset as being "raw" data in the original publication but as "published" data (*i.e.*, background-subtracted) in a response to critics offers a fundamental contradiction: both of those representations cannot be true, and at least one is false. Moreover, it

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[125] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://doi.org/10.48550/arXiv.2111.15017.
[126] *See* Inquiry Report #2 in Exhibit D, (also on file as Attachment 03 – Inquiry Report.pdf starting at page 20, "Exhibit B: Slides by Dias and Salamat describing the user-defined background procedure").
[127] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://doi.org/10.48550/arXiv.2111.15017.
[128] *See* Jorge E. Hirsch & Dirk van der Marel, *Incompatibility of published ac magnetic susceptibility of a room temperature superconductor with measured raw data*, MATTER RADIAT. EXTREMES 7, 048401, App. A (2022), https://doi.org/10.1063/5.0088429.
[129] *See* Ranga P. Dias, Choong-Shik Yoo, Viktor V. Struzhkin, Minseob Kim, Takaki Muramatsu, Takahiro Matsuoka, Yasuo Ohishi & Stainislav Sinogeikin, *Superconductivity in highly disordered dense carbon disulfide*, PROC. NATL. ACAD. SCI. USA 110, 11720-11724, Fig. S3 (2013), https://doi.org/10.1073/pnas.1305129110; Ranga P. Dias, Ori Noked & Isaac F. Silvera, *New Phases and Dissociation-Recombination of Hydrogen Deuteride to 3.4 Mbar*, PHYS. REV. LETT. 116, 145501, Fig. S2, (Apr. 8, 2016) https://link.aps.org/doi/10.1103/PhysRevB.93.104107; Ranga P. Dias, Minseob Kim & Choong-Shik Yoo, *Structural transitions and metallization in dense GeS*, PHYS. REV. B 93, 104107, Fig. 2b, (Mar. 15, 2016) https://journals.aps.org/prb/abstract/10.1103/PhysRevB.93.104107.
[130] *See* R. Dias Interview (Jul. 14, 2023) 51:12-54:25.

strains credulity that a highly experienced researcher like Respondent would not understand the difference in these characterizations of data. For these reasons, as well as for all the reasons set forth above, the Committee believes that these data have very likely been falsified and/or fabricated. As indicated in its analysis of **Allegation A.3**, the Investigation Committee concluded that all $\chi$(T) data reported in the Nature 2020 (CSH) Paper likely were falsified and/or fabricated, which includes the 138 GPa dataset at issue here. Based on the way similar data are presented in other publications of Respondent,[131] Respondent understands: (1) the differences between raw data and processed or background-subtracted data; (2) that readers would consider raw data and processed or background-subtracted data to be different; and (3) that readers would expect such differences to be properly represented and described in the manuscript.

Conclusion:

Ignoring the distinctions between "raw" data and "published" data, as described immediately above, despite considerable attention focused on this dataset in subsequent comments and criticisms, indicates that Respondent's actions were, at the very least, carried out knowingly. Such actions represent a significant departure from accepted practices within the research community.

The Investigation Committee finds, based on a preponderance of the evidence, that Respondent's conduct as to this **Allegation A.4** constitutes research misconduct.

### 5. Plagiarism in version 2 of the 2021 arXiv article, responding to criticism of the Nature 2020 (CSH) Paper

Context:

An article by Daniel Garisto in the American Physical Society Physics News online journal[132] presents an allegation that a section from Respondent's 2021 arXiv article,[133] which provided the "measured data" for the Nature 2020 (CSH) Paper, included plagiarized text copied from Dr. Hamlin's 2007 PhD dissertation.[134] This article presents detailed evidence under the section "Allegations of Plagiarism," comparing the text from Dr. Hamlin's PhD dissertation to Respondent's 2021 arXiv article.

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[131] *See* Ranga P. Dias, Choong-Shik Yoo, Viktor V. Struzhkin, Minseob Kim, Takaki Muramatsu, Takahiro Matsuoka, Yasuo Ohishi & Stainislav Sinogeikin, *Superconductivity in highly disordered dense carbon disulfide*, PROC. NATL. ACAD. SCI. USA 110, 11720-11724, Fig. S3 (2013), https://doi.org/10.1073/pnas.1305129110; Ranga P. Dias, Ori Noked & Isaac F. Silvera, *New Phases and Dissociation-Recombination of Hydrogen Deuteride to 3.4 Mbar*, PHYS. REV. LETT. 116, 145501, Fig. S2, (Apr. 8, 2016) https://link.aps.org/doi/10.1103/PhysRevB.93.104107; Ranga P. Dias, Minseob Kim & Choong-Shik Yoo, *Structural transitions and metallization in dense GeS*, PHYS. REV. B 93, 104107, Fig. 2b, (Mar. 15, 2016) https://journals.aps.org/prb/abstract/10.1103/PhysRevB.93.104107.

[132] *See* Daniel Garisto, *Allegations of Scientific Misconduct Mount as Physicist Makes His Biggest Claim Yet*, PHYSICS 16, 40 (2023), https://physics.aps.org/articles/v16/40.

[133] *See* Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017.

[134] James J. H. Hamlin, *Superconductivity at Extreme Pressure* (Dec. 2007) (PhD Dissertation, Washington University), *available at* http://www.phys.ufl.edu/~jhamlin/Hamlin_thesis.pdf.

Evidence:

- When presented with this information during his interview with the Investigation Committee, Respondent suggested that the language in question from the 2021 arXiv article was copied from his own PhD dissertation.[135] However, the Investigation Committee reviewed Respondent's PhD dissertation,[136] Dr. Hamlin's PhD dissertation,[137] and the 2021 arXiv article,[138] and found at least one sentence in Respondent's 2021 arXiv article that appeared in Dr. Hamlin's PhD dissertation but not in Respondent's PhD dissertation. During a later interview, Respondent again denied any plagiarism, despite the Investigation Committee's presentation of contradictory evidence.[139]
- A preponderance of evidence indicates that Respondent, and not Respondent's only co-author on this 2021 arXiv article (Interviewee 7), committed the plagiarism in question, despite Respondent's denial of such action during his interview with the Investigation Committee. This evidence includes the following:
    - Interviewee 7 denied personal responsibility for any plagiarized text during his interview with the Investigation Committee, and the Committee judged him credible on this point.[140]
    - The author contribution statements for the Nature 2020 (CSH) Paper and the Nature 2023 (LuH) Paper statements assign responsibility for the a.c. magnetic susceptibility measurements and analysis to Respondent, but not to Interviewee 7.[141]
    - Respondent's PhD dissertation includes a.c. magnetic-susceptibility measurements that were later published in Proceedings of the National Academy of Sciences of the United States ("PNAS"),[142] on which he was first author, indicating that Respondent has expertise that is relevant to the arXiv publication sections pertaining to the a.c. susceptibility measurements.

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[135] *See* R. Dias Interview (Jul. 7, 2023) 75:25-76:12.
[136] *See* Original 2013 Version of Ranga P. Dias, *Phase Transitions, Metallization, Superconductivity and Magnetic Ordering in Dense Carbon Disulfide and Chemical Analogs* (Jul. 2013) (PhD Dissertation, Washington State University), *available at* https://rex.libraries.wsu.edu/esploro/outputs/doctoral/PHASE-TRANSITIONS-METALLIZATION-SUPERCONDUCTIVITY-AND-MAGNETIC/99900581648701842.
[137] James J. H. Hamlin, *Superconductivity at Extreme Pressure* (Dec. 2007) (PhD Dissertation, Washington University), *available at* http://www.phys.ufl.edu/~jhamlin/Hamlin_thesis.pdf.
[138] *See* Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, ARXIV (2021), https://arxiv.org/abs/2111.15017.
[139] *See* R. Dias Interview (Jul. 14, 2023) 42:5-49:19.
[140] *See* Interviewee 7 Interview (Oct. 2, 2023) 21:2-15.
[141] The author contribution statement for the Nature 2020 (CSH) paper states (emphasis added): "M.D. provided technical support during the initial stage of the electrical conductivity measurements, performed magnetic susceptibility measurements and contributed to the writing of the paper. **R.P.D. [Respondent]** conceived the project and performed electrical conductivity and magnetic susceptibility experiments**.** K.V.L. and A.S. analysed the data and the chemistry protocol." Similarly, the author contribution statement for the Nature 2023 (LuH) paper states (emphasis added): "N.D.-G., N.K.-S., S.M., S.E.D. and **R.P.D. [Respondent]** contributed to performing a.c. magnetic-susceptibility measurements and analysed the data."
[142] Ranga P. Dias, Choong-Shik Yoo, Viktor V. Struzhkin & Stanislav Sinogeikin, *Superconductivity in highly disordered dense carbon disulfide*, PROC. NATL. ACAD. SCI. USA 110, 11720-11724, https://doi.org/10.1073/pnas.1305129110.

- Respondent has been accused of plagiarism in his 2013 PhD dissertation and on Respondent's research websites,[143] and there is clear evidence of plagiarism in other documentation prepared and submitted to external reviewers by Respondent, including as described in **Allegation E** (below). As discussed in Section V (Recommendations), a revised PhD dissertation was uploaded to the WSU repository in September 2023,[144] which differs significantly from the original 2013 version.

Findings/Reasoning:

The Investigation Committee was able to verify the overlap in text between the 2021 arXiv article and Dr. Hamlin's PhD dissertation, despite Respondent's denial of any such plagiarism. The Investigation Committee also found Interviewee 7's denial of responsibility to be credible. Taking all evidence together, it appears that Respondent likely copied, pasted, and integrated sections of text from Dr. Hamlin's PhD dissertation. According to guidelines from the National Science Foundation Office of Inspector General,[145] this behavior clearly constitutes acts of copying, pasting, and integrating, and therefore plagiarism. These facts, along with other apparent instances of plagiarism by Respondent, strongly indicate plagiarism that rises to the level of intentional conduct.

Conclusion:

Given the number of independent instances of alleged plagiarism in Respondent's work (as outlined herein), some of which appear to be beyond refute, the logical conclusion is that (1) these acts of plagiarism were carried out by Respondent with intention and (2) this particular instance of alleged plagiarism in the 2021 arXiv article has merit and was carried out with intention.[146] This represents a significant departure from accepted practices within the research community.

Accordingly, the Investigation Committee finds, based on a preponderance of the evidence, that Respondent's conduct as to this **Allegation A.5** constitutes research misconduct.

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[143] *See* discussion in Daniel Garisto, *Plagiarism allegations pursue physicist behind stunning superconductivity claims*, SCIENCE (Apr. 13, 2023), https://www.science.org/content/article/plagiarism-allegations-pursue-physicist-behind-stunning-superconductivity-claims.

[144] Revised September 2023 Version of Ranga P. Dias, *Phase Transitions, Metallization, Superconductivity and Magnetic Ordering in Dense Carbon Disulfide and Chemical Analogs* (Jul. 2013) (PhD Dissertation, Washington State University), *available at* https://rex.libraries.wsu.edu/esploro/outputs/doctoral/PHASE-TRANSITIONS-METALLIZATION-SUPERCONDUCTIVITY-AND-MAGNETIC/99900581648701842.

[145] National Science Foundation Office of Inspector General, *Assessing Intent in Verbatim Plagiarism Investigations*, *available at* https://oig.nsf.gov/sites/default/files/document/2021-10/Assessing%20Intent%20In%20Verbatim%20Plagiarism%20Investigations_0.pdf.

[146] *Id*.

## B. PRL 2021 ($MnS_2$) Paper

### 1. Fabrication and/or falsification of Figure 1b, R(T) data (resistance as a function of temperature)

Context:

The PRL 2021 ($MnS_2$) Paper describes a combination of measurements and numerical simulations claiming evidence for an insulator-to-metal transition in $MnS_2$ upon pressure increase above 12 GPa, followed by a metal-to-insulator transition when pressure is further increased above 36 GPa. A key piece of evidence is provided by low temperature electrical resistance measurements shown in **Figure 1b**, which reveal that R(T) exhibits the characteristics of a metal (R increases with increasing T) at 13, 16, and 26 GPa, while both at lower pressure (3.5 GPa) and higher pressure (36 and 52 GPa) R(T) exhibits characteristics of an insulator or semiconductor (R decreases with increasing T).

Table and Figures for Reference:

| Dataset | Method obtained by Investigation Committee | Path or archive location | Filename |
|---|---|---|---|
| 13.5 GPa $GeSe_4$ data from Respondent's PhD dissertation | Interviewee 7 | N/A | GeSe4_13pt5GPa.csv |
| 16 GPa $GeSe_4$ data from Respondent's PhD dissertation | Interviewee 7 | N/A | GeSe4_16GPa.csv |
| 24 GPa $GeSe_4$ data from Respondent's PhD dissertation | Interviewee 7 | N/A | GeSe4_24GPa.csv |
| 13 GPa $MnS_2$ data from Respondent | Respondent | N/A | 13GPa.csv |
| 16 GPa $MnS_2$ data from Respondent | Respondent | N/A | 16GPa.csv |
| 26 GPa $MnS_2$ data from Respondent | Respondent | N/A | 26GPa.csv |
| 13, 16, and 26 GPa $MnS_2$ data emailed to Interviewee 3 by Respondent | Interviewee 3 | N/A | MnS2.dat |
| 13 GPa $MnS_2$ data extracted from PRL Figure 1b | Dr. Hamlin's GitHub repository | N/A | 13_GPa_higher_res.csv |
| 16 GPa $MnS_2$ data extracted from PRL Figure 1b | Dr. Hamlin's GitHub repository | N/A | 16_GPa.csv |
| 26 GPa $MnS_2$ data extracted from PRL Figure 1b | Dr. Hamlin's GitHub repository | N/A | 26_GPa.csv |
| Raw data for 36 GPa $MnS_2$ measurement | Sequestered hard drive from Respondent's lab | 9-10-19 Salamat MnS2/9-11-19 | 9-11-19 MnS2 warm run.csv |
| Raw data for 52 GPa $MnS_2$ measurement | Sequestered hard drive from Respondent's lab | 9-10-19 Salamat MnS2/9-12-19 | 9-12-19 MnS2 warm run.csv |

**Table $MnS_2$_1:** Summary of data files relevant to Figure 1b. of the PRL 2021 ($MnS_2$) Paper.

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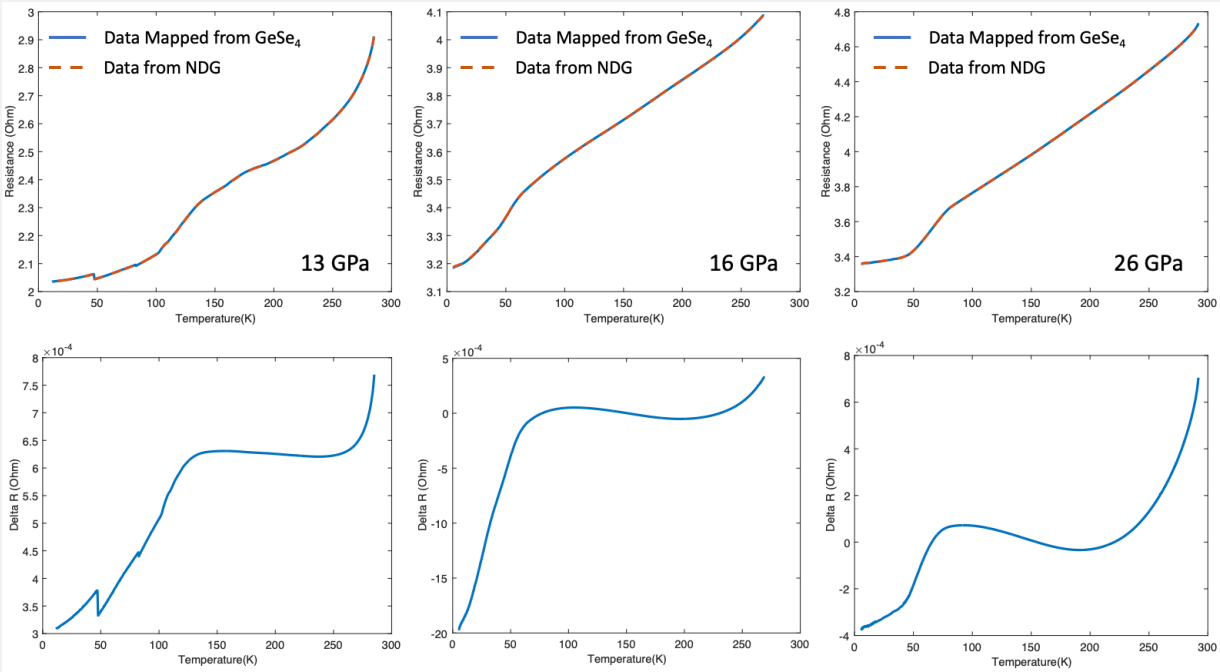


**Figure $MnS_2$_1: Analysis by the Investigation Committee: Upper Plots:** comparison of R(T) curves obtained by rescaling the $GeSe_4$ data provided by Interviewee 7 to the Investigation Committee[147] (these $GeSe_4$ data were sent via email by Respondent to Interviewee 7 on Mar. 15, 2023) using the mathematical function with four adjustable parameters identified by Anonymous Reviewer Gamma (blue) and R(T) curves for $MnS_2$ obtained from the data sent to Interviewee 3 from Respondent contained within the file named "MnS2.dat"[148] (dashed orange). **Bottom Plots:** the difference between the two curves in the Upper Plots (*i.e.*, the dashed orange curve minus the blue curve) over the common range of temperature. Note that the lack of noise in the difference plots (bottom plots) demonstrates that the noise features between the corresponding datasets are identical (*i.e.*, the noise features arise from the same measurement and the two curves are scaled versions of the same data). The very small (but non-zero) difference indicates that the mathematical function with four adjustable parameters identified by Anonymous Reviewer Gamma is not quite optimized. However, Anonymous Reviewer Gamma did not have access to the same data as the Investigation Committee, but rather only had access to data provided by Respondent (see **Allegation B.2**) or data extracted from published figures using a vector-based extraction method.

[147] $GeSe_4$ Data Files (on file as GeSe4_13pt5GPa.csv, GeSe4_16PGPa.csv, GeSe4_24GPa.csv) (Data sent by Respondent to Interviewee 7 via email on Mar. 13, 2023 and provided by Interviewee 7 to the Investigation Committee).

[148] $MnS_2$ data file (on file as MnS2.dat) (Data sent by Respondent to Interviewee 3 by email on Oct. 23, 2019 and provided by Interviewee 3 to the Investigation Committee).

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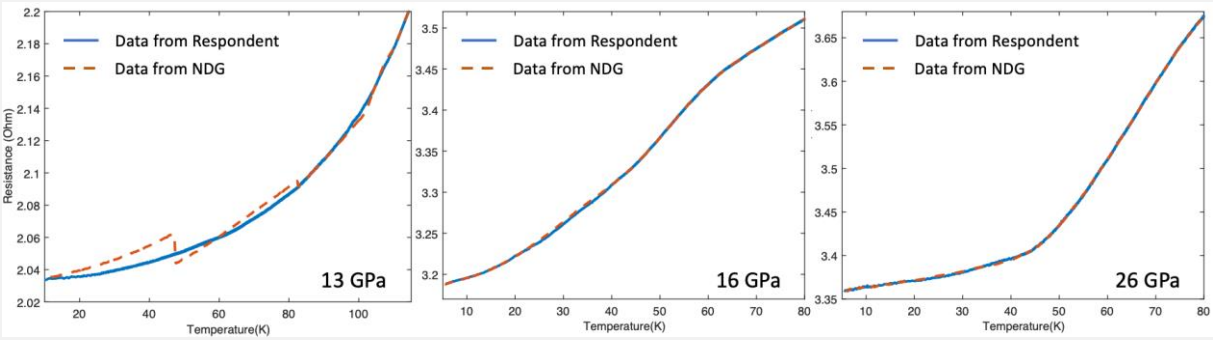


**Figure $MnS_2$_2: Analysis by the Investigation Committee:** Investigation Committee's comparisons of the data sent to Interviewee 3 from Respondent contained within the file named "MnS2.dat"[149] (dashed orange) with the data provided by Respondent to PRL and to the Investigation Committee (blue). These comparisons highlight the low temperature region which exhibit the largest differences: in particular for the data at 13 GPa where the data from the file named "MnS2.dat" (dashed orange) exhibit abrupt drops in resistance near 47 and 82 K, while no abrupt drops are present in the data provided by Respondent to the Investigation Committee (blue).

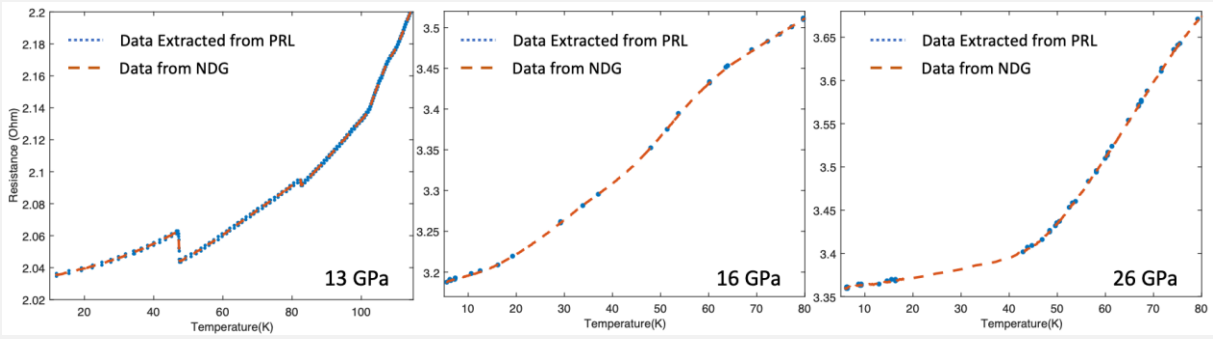


**Figure $MnS_2$_3: Analysis by the Investigation Committee:** Investigation Committee's comparisons of the data sent to Interviewee 3 from Respondent (data file named "MnS2.dat") (dashed orange) with the data extracted by Dr. Hamlin from Figure 1b of the PRL 2021 ($MnS_2$) Paper using a vector-based extraction method (blue dots).[150] These comparisons highlight the low temperature region where the largest differences were observed between the data sent to Interviewee 3 from Respondent with the data provided by Respondent to the Investigation Committee (see Figure $MnS_2$_2), in particular for the data at 13 GPa where the data from the file named "MnS2.dat" (dashed orange) exhibit abrupt drops in resistance near 47 and 82 K, in agreement with abrupt drops present in the data extracted from Figure 1b of the PRL 2021 ($MnS_2$) Paper (blue dots).

[149] *Id*.

[150] *Id*.; data extracted by Dr. Hamlin (on file as 13_GPa_higher_res [Downloaded 2023-12-13, 3.51pm PT].csv, 16_GPa [Downloaded 2023-12-13, 3.51pm PT].csv, 26_GPa [Downloaded 2023-12-13, 3.51pm PT].csv), *also available at* https://github.com/jhamlin-ufl/vextract/tree/main/data/extracted_data/MnS2 (File names on GitHub: 13_GPa_higher_res.csv, 16_GPa.csv, 26_GPa.csv).

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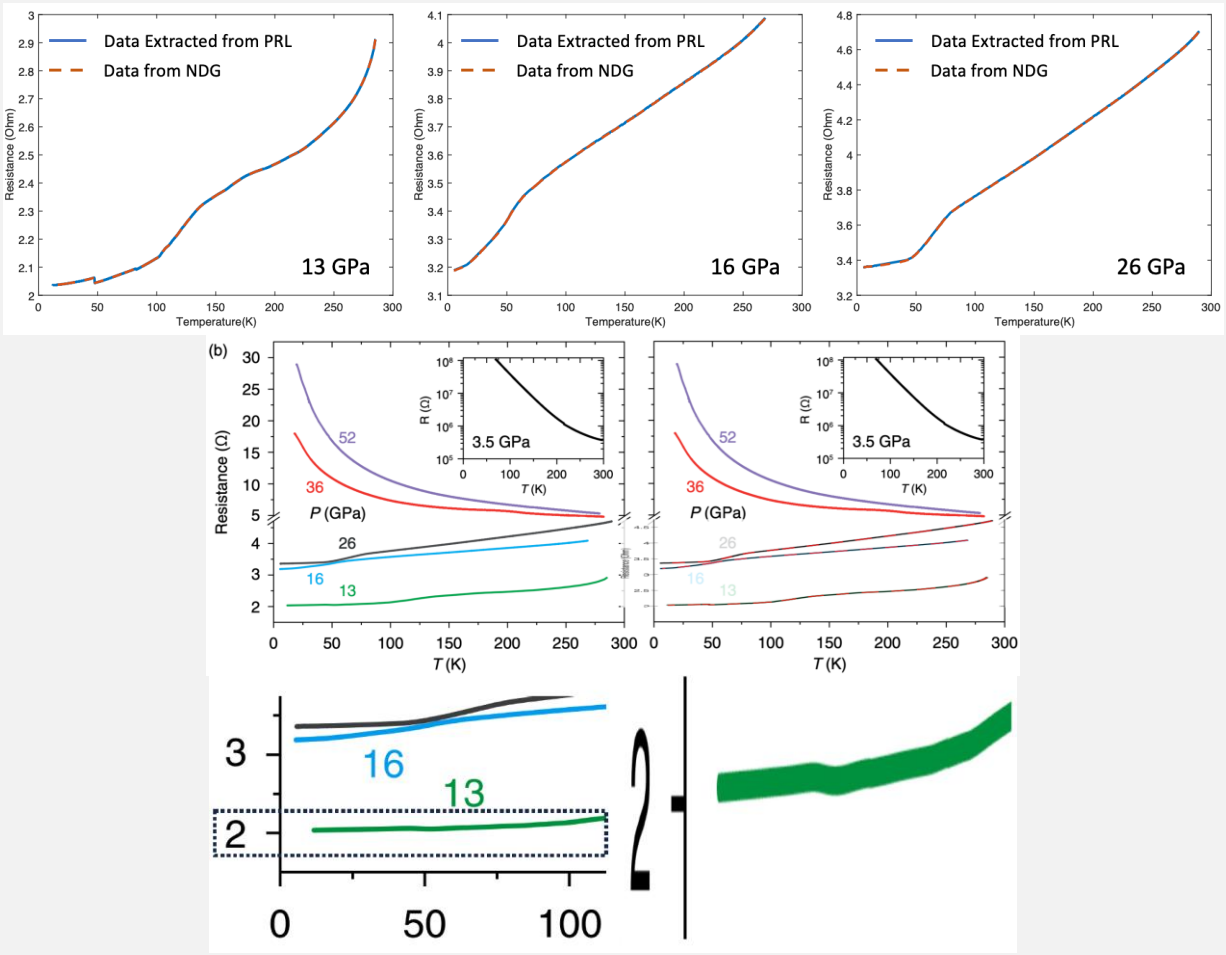


**Figure $MnS_2$_4: Analysis by the Investigation Committee: Upper Plots:** Investigation Committee's comparisons of the data sent to Interviewee 3 from Respondent (data file named "MnS2.dat") (dashed orange) with the data extracted by Dr. Hamlin from Figure 1b of the PRL 2021 ($MnS_2$) Paper using a vector-based extraction method (blue) over the full temperature range. **Center Plots: (Left)** Figure 1b from PRL 2021 ($MnS_2$) Paper.[151] **(Right)** Same figure overlayed with both the data sent to Interviewee 3 from Respondent contained within the file named "MnS2.dat" (dashed red) and the data extracted by Dr. Hamlin from Figure 1b of the PRL 2021 ($MnS_2$) Paper using a vector-based extraction method (black). **Bottom Plots: (Left)** Expanded views of Figure 1b of the PRL 2021 ($MnS_2$) Paper. **(Right)** Expanded view of the dotted box of the left panel, expanded along the Resistance axis to reveal the abrupt changes in slope near 47 and 82K.

[151] $MnS_2$ data file (on file as MnS2.dat) (data sent by Respondent to Interviewee 3 by email on October 23, 2019); data extracted by Dr. Hamlin (on file as 13_GPa_higher_res [Downloaded 2023-12-13, 3.51pm PT].csv, 16_GPa [Downloaded 2023-12-13, 3.51pm PT].csv, 26_GPa [Downloaded 2023-12-13, 3.51pm PT].csv), *also available at*: https://github.com/jhamlin-ufl/vextract/tree/main/data/extracted_data/MnS2 (File names on GitHub: 13_GPa_higher_res.csv, 16_GPa.csv, 26_GPa.csv).

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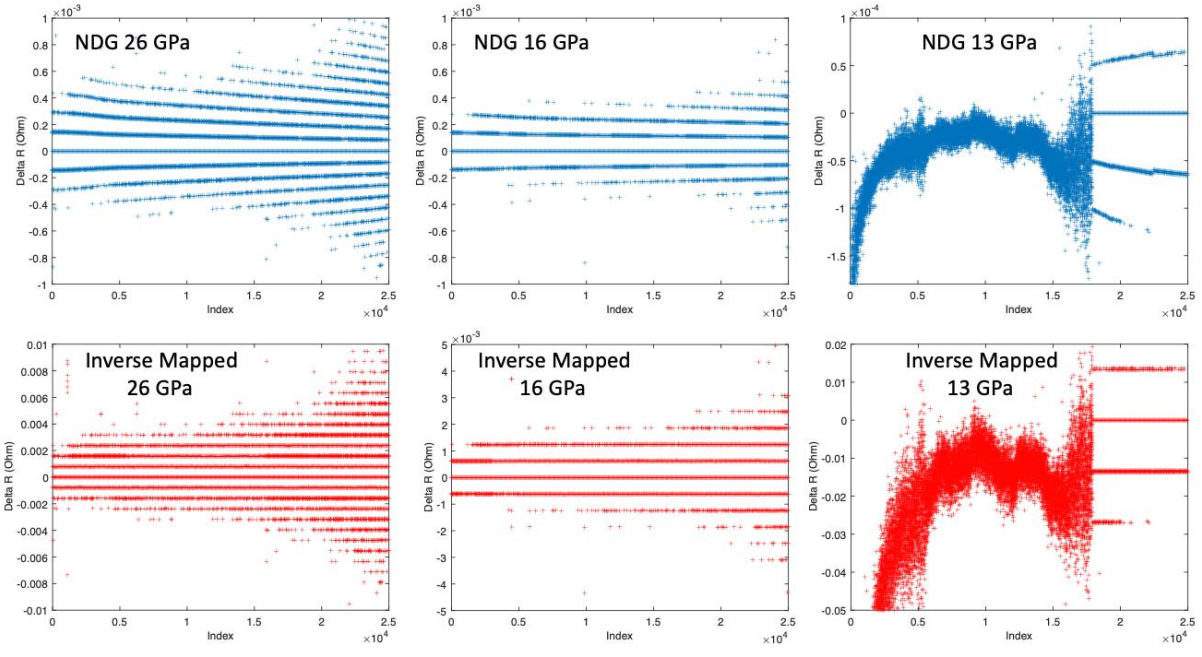


**Figure $MnS_2$_5: Analysis by the Investigation Committee: Upper plots:** First differences in resistance vs. index for the data sent to Interviewee 3 from Respondent (data file named "MnS2.dat").[152] Data exhibit unusual patterns reminiscent of a signal with strong digitization noise (First differences are spread over a finite set of values) but that appear distorted. **Lower plots:** Same data mapped (rescaled) with the inverse of the mathematical function discovered by Anonymous Reviewer Gamma from the post-publication review (*i.e.*, mapping it back to the $GeSe_4$ data). Once mapped (rescaled) back to match the $GeSe_4$ data, the first difference of the $MnS_2$ data now exhibit plausible digitization patterns.

[152] $MnS_2$ data file (on file as MnS2.dat) (data sent by Respondent to Interviewee 3 by email on Oct. 23, 2019).

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| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GeSe4 at 16 GPa | | MnS2 at 26 GPa | | GeSe4 at 24 GPa | | MnS2 at 16 GPa | | GeSe4 at 13.5 GPa | | MnS2 at 13 GPa | |
| 2 | T | R | T | R | T | R | T | R | T | R | T | R |
| 3 | 5.808755 | 7.9531489 | 5.808755 | 3.3592947 | 5.503487 | 7.5369167 | 5.503487 | 3.187837 | 11.7664 | 71.060694 | 11.7664 | 2.0351892 |
| 4 | 5.819715 | 7.9539574 | 5.819715 | 3.3594425 | 5.514616 | 7.5363 | 5.514616 | 3.1876999 | 11.77705 | 71.074422 | 11.77705 | 2.0352547 |
| 5 | 5.830923 | 7.9539574 | 5.830923 | 3.3594425 | 5.525538 | 7.5356833 | 5.525538 | 3.1875628 | 11.78772 | 71.074422 | 11.78772 | 2.0352547 |
| 6 | 5.842341 | 7.9539574 | 5.842341 | 3.3594425 | 5.536529 | 7.5356833 | 5.536529 | 3.1875628 | 11.7984 | 71.074422 | 11.7984 | 2.0352547 |
| 7 | 5.853858 | 7.9547234 | 5.853858 | 3.3595824 | 5.547541 | 7.5356833 | 5.547541 | 3.1875628 | 11.80909 | 71.087789 | 11.80909 | 2.0353185 |
| 8 | 5.865376 | 7.9555319 | 5.865376 | 3.3597301 | 5.558478 | 7.5363 | 5.558478 | 3.1876999 | 11.8198 | 71.087789 | 11.8198 | 2.0353185 |
| 9 | 5.876873 | 7.9547234 | 5.876873 | 3.3595824 | 5.569497 | 7.5363 | 5.569497 | 3.1876999 | 11.83051 | 71.087789 | 11.83051 | 2.0353185 |
| 10 | 5.888388 | 7.9547234 | 5.888388 | 3.3595824 | 5.579568 | 7.5369167 | 5.579568 | 3.187837 | 11.84124 | 71.101156 | 11.84124 | 2.0353823 |
| 11 | 5.899821 | 7.9547234 | 5.899821 | 3.3595824 | 5.590004 | 7.5369167 | 5.590004 | 3.187837 | 11.85198 | 71.101156 | 11.85198 | 2.0353823 |
| 12 | 5.911132 | 7.9547234 | 5.911132 | 3.3595824 | 5.600757 | 7.5369167 | 5.600757 | 3.187837 | 11.86273 | 71.114884 | 11.86273 | 2.0354478 |
| 13 | 5.922235 | 7.9547234 | 5.922235 | 3.3595824 | 5.61134 | 7.5369167 | 5.61134 | 3.187837 | 11.87349 | 71.114884 | 11.87349 | 2.0354478 |
| 14 | 5.933158 | 7.9555319 | 5.933158 | 3.3597301 | 5.622382 | 7.5369167 | 5.622382 | 3.187837 | 11.88427 | 71.114884 | 11.88427 | 2.0354478 |
| 15 | 5.944029 | 7.9555319 | 5.944029 | 3.3597301 | 5.633049 | 7.5369167 | 5.633049 | 3.187837 | 11.89507 | 71.128251 | 11.89507 | 2.0355115 |
| 16 | 5.954898 | 7.9555319 | 5.954898 | 3.3597301 | 5.644168 | 7.5369167 | 5.644168 | 3.187837 | 11.90587 | 71.128251 | 11.90587 | 2.0355115 |
| 17 | 5.96573 | 7.9547234 | 5.96573 | 3.3595824 | 5.654616 | 7.5369167 | 5.654616 | 3.187837 | 11.91668 | 71.128251 | 11.91668 | 2.0355115 |
| 18 | 5.976489 | 7.9547234 | 5.976489 | 3.3595824 | 5.664727 | 7.5369167 | 5.664727 | 3.187837 | 11.9275 | 71.141618 | 11.9275 | 2.0355753 |
| 19 | 5.987217 | 7.9539574 | 5.987217 | 3.3594425 | 5.675248 | 7.53755 | 5.675248 | 3.1879777 | 11.93833 | 71.141618 | 11.93833 | 2.0355753 |
| 20 | 5.997893 | 7.9531489 | 5.997893 | 3.3592947 | 5.685384 | 7.5381667 | 5.685384 | 3.1881148 | 11.94917 | 71.141618 | 11.94917 | 2.0355753 |
| 21 | 6.00843 | 7.9523404 | 6.00843 | 3.359147 | 5.696551 | 7.5381667 | 5.696551 | 3.1881148 | 11.96003 | 71.154986 | 11.96003 | 2.035639 |
| 22 | 6.01872 | 7.9515745 | 6.01872 | 3.3590071 | 5.707232 | 7.5381667 | 5.707232 | 3.1881148 | 11.9709 | 71.154986 | 11.9709 | 2.035639 |
| 23 | 6.02884 | 7.950766 | 6.02884 | 3.3588593 | 5.718369 | 7.5387833 | 5.718369 | 3.1882518 | 11.98178 | 71.154986 | 11.98178 | 2.035639 |
| 24 | 6.04026 | 7.9515745 | 6.04026 | 3.3590071 | 5.729687 | 7.5394 | 5.729687 | 3.1883889 | 11.99269 | 71.154986 | 11.99269 | 2.035639 |
| 25 | 6.0503 | 7.9515745 | 6.0503 | 3.3590071 | 5.740035 | 7.5394 | 5.740035 | 3.1883889 | 12.0036 | 71.154986 | 12.0036 | 2.035639 |
| 26 | 6.06043 | 7.9523404 | 6.06043 | 3.359147 | 5.750728 | 7.5400333 | 5.750728 | 3.1885296 | 12.01452 | 71.154986 | 12.01452 | 2.035639 |
| 27 | 6.07061 | 7.9523404 | 6.07061 | 3.359147 | 5.76136 | 7.5400333 | 5.76136 | 3.1885296 | 12.02546 | 71.154986 | 12.02546 | 2.035639 |
| 28 | 6.0808 | 7.9523404 | 6.0808 | 3.359147 | 5.771397 | 7.5400333 | 5.771397 | 3.1885296 | 12.0364 | 71.154986 | 12.0364 | 2.035639 |
| 29 | 6.09096 | 7.9523404 | 6.09096 | 3.359147 | 5.782327 | 7.5394 | 5.782327 | 3.1883889 | 12.04737 | 71.154986 | 12.04737 | 2.035639 |
| 30 | 6.10108 | 7.9515745 | 6.10108 | 3.3590071 | 5.793033 | 7.5400333 | 5.793033 | 3.1885296 | 12.05835 | 71.154986 | 12.05835 | 2.035639 |
| 31 | 6.11248 | 7.950766 | 6.11248 | 3.3588593 | 5.803696 | 7.54065 | 5.803696 | 3.1886666 | 12.06934 | 71.154986 | 12.06934 | 2.035639 |
| 32 | 6.12378 | 7.950766 | 6.12378 | 3.3588593 | 5.81412 | 7.54065 | 5.81412 | 3.1886666 | 12.08034 | 71.154986 | 12.08034 | 2.035639 |
| 33 | 6.13503 | 7.9515745 | 6.13503 | 3.3590071 | 5.824647 | 7.54065 | 5.824647 | 3.1886666 | 12.09135 | 71.154986 | 12.09135 | 2.035639 |
| 34 | 6.14634 | 7.9531489 | 6.14634 | 3.3592947 | 5.835033 | 7.5412667 | 5.835033 | 3.1888036 | 12.10237 | 71.154986 | 12.10237 | 2.035639 |
| 35 | 6.15776 | 7.9547234 | 6.15776 | 3.3595824 | 5.845376 | 7.5412667 | 5.845376 | 3.1888036 | 12.11339 | 71.168714 | 12.11339 | 2.0357045 |
| 36 | 6.16785 | 7.9547234 | 6.16785 | 3.3595824 | 5.856298 | 7.5418833 | 5.856298 | 3.1889406 | 12.12443 | 71.168714 | 12.12443 | 2.0357045 |
| 37 | 6.17794 | 7.9547234 | 6.17794 | 3.3595824 | 5.867237 | 7.5412667 | 5.867237 | 3.1888036 | 12.13548 | 71.168714 | 12.13548 | 2.0357045 |
| 38 | 6.18935 | 7.9539574 | 6.18935 | 3.3594425 | 5.877728 | 7.5412667 | 5.877728 | 3.1888036 | 12.14654 | 71.168714 | 12.14654 | 2.0357045 |
| 39 | 6.20058 | 7.9547234 | 6.20058 | 3.3595824 | 5.888677 | 7.5412667 | 5.888677 | 3.1888036 | 12.15761 | 71.168714 | 12.15761 | 2.0357045 |
| 40 | 6.2117 | 7.9555319 | 6.2117 | 3.3597301 | 5.898766 | 7.5412667 | 5.898766 | 3.1888036 | 12.16869 | 71.168714 | 12.16869 | 2.0357045 |
| 41 | 6.2229 | 7.9571064 | 6.2229 | 3.3600177 | 5.908933 | 7.5412667 | 5.908933 | 3.1888036 | 12.17978 | 71.168714 | 12.17978 | 2.0357045 |
| 42 | 6.23419 | 7.9579149 | 6.23419 | 3.3601653 | 5.919233 | 7.5412667 | 5.919233 | 3.1888036 | 12.19089 | 71.168714 | 12.19089 | 2.0357045 |
| 43 | 6.24558 | 7.9586809 | 6.24558 | 3.3603052 | 5.929703 | 7.5418833 | 5.929703 | 3.1889406 | 12.202 | 71.168714 | 12.202 | 2.0357045 |
| 44 | 6.25689 | 7.9579149 | 6.25689 | 3.3601653 | 5.940325 | 7.5418833 | 5.940325 | 3.1889406 | 12.21312 | 71.154986 | 12.21312 | 2.035639 |
| 45 | 6.26806 | 7.9571064 | 6.26806 | 3.3600177 | 5.951027 | 7.5431333 | 5.951027 | 3.1892183 | 12.22426 | 71.154986 | 12.22426 | 2.035639 |
| 46 | 6.27909 | 7.9571064 | 6.27909 | 3.3600177 | 5.961725 | 7.5431333 | 5.961725 | 3.1892183 | 12.23541 | 71.154986 | 12.23541 | 2.035639 |
| 47 | 6.28997 | 7.9562979 | 6.28997 | 3.35987 | 5.972462 | 7.5431333 | 5.972462 | 3.1892183 | 12.24657 | 71.154986 | 12.24657 | 2.035639 |
| 48 | 6.3008 | 7.9555319 | 6.3008 | 3.3597301 | 5.983299 | 7.5431333 | 5.983299 | 3.1892183 | 12.25774 | 71.154986 | 12.25774 | 2.035639 |
| 49 | 6.31145 | 7.9555319 | 6.31145 | 3.3597301 | 5.994373 | 7.5431333 | 5.994373 | 3.1892183 | 12.26892 | 71.154986 | 12.26892 | 2.035639 |

**Figure $MnS_2$_6:** Screenshot comparing data series from the $GeSe_4$ data (obtained from Interviewee 7) and the $MnS_2$ data (obtained from Interviewee 3) over the range of common temperature.[153] Columns A and B: data contained in file GeSe4_16GPa.csv; columns C and D: data contained in the first two columns of file MnS2.dat; columns E and F: data contained in file GeSe4_24GPa.csv; columns G and H: data contained in the third and fourth columns of file MnS2.dat; columns I and J: data contained in file GeSe4_13pt5GPa.csv; columns K and L: data contained in the fifth and sixth columns of file MnS2.dat. Note the perfect agreement in columns A and C (temperature series for $GeSe_4$ data at 16 GPa and $MnS_2$ data at 26 GPa), columns E and G (temperature series for $GeSe_4$ data at 24 GPa and $MnS_2$ data at 16 GPa), and columns I and K (temperature series for $GeSe_4$ data at 13.5 GPa and $MnS_2$ data at 13 GPa).

[153] In this analysis, the data from file MnS2.dat at 13 GPa were reordered (reversed) so that the temperature series is displayed in ascending order, and temperature values below 11.7664 were deleted to match the starting value of the temperature series from file GeSe4_13pt5GPa.csv.

Evidence:

- In an email sent on October 27, 2022 to *PRL* editors and co-authors of the PRL 2021 ($MnS_2$) Paper, Dr. Hamlin raised a concern "that several of the electrical resistance datasets appearing in **Figure 1b** (of the $MnS_2$ publication), purportedly for $MnS_2$, bear a striking resemblance to the electrical resistance datasets for $GeSe_4$ published in the PhD dissertation of L. P. Dias (2013)."[154] This allegation prompted the *PRL* editors to initiate a post-publication review of the PRL 2021 ($MnS_2$) Paper.
- Anonymous Reviewer Gamma from the post-publication review identified a mathematical function with four adjustable parameters that convincingly maps three of the high pressure $GeSe_4$ Resistance vs Temperature R(T) curves (at 13.5, 24, and 16 GPa) reported in Respondent's PhD dissertation onto three $MnS_2$ R(T) curves (at 13, 16, and 26 GPa) published in the PRL 2021 ($MnS_2$) Paper.[155] The Investigation Committee was able to reproduce the analysis, thereby confirming the validity of the Anonymous Reviewer Gamma's analysis. The mapping is accurate to the fourth or fifth significant digit for all three R(T) curves over the entire temperature range presented.[156]
- *PRL* provided the findings of the post-publication review to all co-authors on July 10, 2023, in which correspondence *PRL* editors noted that, based on those findings, the journal was "no longer confident in the integrity of the data presented in Figure 1 of the paper."[157] Based on the findings of the post-publication review, *PRL* editors retracted the paper on August 15, 2023. Presented with the post-publication review findings, all the authors, including Dylan Durkee, Nathan Dasenbrock-Gammon, G. Alexander Smith, Elliot Snider, Dean Smith, Christian Childs, Simon A. J. Kimber, Keith V. Lawler, and Ashkan Salamat, agreed with the retraction—except Respondent.[158]

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[154] Email from James Hamlin to *PRL* and Co-Authors of PRL 2021 ($MSN_2$) Paper (Oct. 27, 2022) (on file as Attachment 13 – Comment on PRL.pdf) (emphasis added):

> I recently noticed that several of the electrical resistance data sets appearing in Fig. 1b, purportedly for $MnS_2$, **bear a striking resemblance to electrical resistance data sets for $GeSe_4$ published in the PhD dissertation of L. P. Dias (2013)**. Considering only the data below 120 K, three different pairs of data sets exhibit identical shapes with the limitations of the digitization methods. It is impossible to reasonably conclude that this could occur by chance. Therefore, the electrical resistance data can no longer be considered reliable. A brief description of my findings is detailed in the attached document. Upon request, I am willing [to] share the code that I used to perform my analysis and generated the plots in the attached document. I ask that the editors and authors determine what corrective action would be most appropriate.

[155] *See* Independent comparison of resistance data in PRL 127, 016401 (2021) and in the dissertation of R. P. Dias (2013): Reviewer Gamma (on file as Report Gamma.pdf).

[156] *See* Figure $MnS_2$_1, above.

[157] Email from *PRL* to Authors of PRL 2021 ($MnS_2$) Paper (Jul. 10, 2023, 7:27pm) (on file as PRL Email Notification_CONFIDENTIAL INFORMATION_ [EXT] LB17112 D_160944_1.pdf).

[158] Dylan Durkee, Nathan Dasenbrock-Gammon, G. Alexander Smith, Elliot Snider, Dean Smith, Christian Childs, Simon A. J. Kimber, Keith V. Lawler & Ashkan Salamat, *Retraction: Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator MnS 2 [Phys. Rev. Lett. 127, 016401 (2021)]*, PHYS. REV. LETT. 131, 079902 (Aug. 15, 2023), https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.131.079902.

- During separate interviews with the Investigation Committee, Interviewee 3,[159] Interviewee 6,[160] and Interviewee 5[161] each stated that two of the five low-temperature R(T) curves for $MnS_2$ (at 36 and 52 GPa) were measured at Respondent's laboratory at the University by Interviewee 5, Interviewee 8, Interviewee 3, and another student (then-current students in Respondent's laboratory at the University and Interviewee 7's laboratory at UNLV). No interviewee could positively identify the source of the other three low-temperature R(T) curves in question (at 13, 16, and 26 GPa), other than noting that these data were sent to Interviewee 3 by Respondent (discussed further below). In addition, none of the aforementioned students found raw datasets for these experiments within records of Respondent's laboratory. In contrast, a folder located by the Investigation Committee on sequestered hard drives from Respondent's laboratory, named "9-10-19 Salamat MnS2," contains raw data for the 36 GPa curve,[162] raw data for the 52 GPa curve,[163] and the picture used as an insert in **Figure 1** of the PRL 2021 ($MnS_2$) Paper.[164] The absence of raw data for the R(T) curves at 13 GPa, 16 GPa, and 26 GPa on sequestered hard drives from Respondent's laboratory and the lack of any information regarding these measurements within the records from Respondent's laboratory directly contradicts Respondent's statements that all data for the PRL 2021 ($MnS_2$) Paper were collected in Respondent's laboratory at the University, and that the data would be on his laboratory computers and details of the experiments recorded in logbooks.[165] Respondent's statements are further contradicted by the evidence discussed here, which demonstrates that the R(T) curves in question were fabricated using data for $GeSe_4$ that was first presented in Respondent's PhD dissertation several years prior to Respondent joining the University.
- On October 23, 2019, Respondent emailed a file titled "MnS2.dat" to Interviewee 3.[166] The file consists of six data columns, each containing 25,180 data points. The first and second columns, third and fourth columns, and fifth and sixth columns contain the R(T) data reported for $MnS_2$ at 26, 16, and 13 GPa, respectively.[167]
    - Data from "MnS2.dat" ***do not*** match data provided by Respondent to *PRL* during the post-publication process or to the Investigation Committee (see **Allegation B.2** below).[168] However, data from "MnS2.dat" ***do*** match the low-temperature R(T) curves extracted from the PRL 2021 ($MnS_2$) Paper by Dr. Hamlin using a vector-based extraction method. In particular, for the 13 GPa dataset, both data from "MnS2.dat" and data extracted from the PRL 2021 ($MnS_2$) Paper exhibit abrupt drops in resistance near 47 and 82 K, but these abrupt drops are not present in the data provided by Respondent to *PRL* or to the Investigation Committee.[169]

[159] *See* Interviewee 3 Interview (Jul. 20, 2023) 12:16-14:8.
[160] *See* Interviewee 6 Interview (Jul. 20, 2023) 54:5-55:6.
[161] *See* Interviewee 5 Interview (Jul. 20, 2023) 14:23-15:14, 25:2-26:12.
[162] Sequestered warm run raw data 9-11-19 (on file as 9-11-19 MnS2 warm run.csv).
[163] Sequestered warm run raw data 9-12-19 (on file as 9-12-19 MnS2 warm run.csv).
[164] Figure insert to PRL 2021 ($MnS_2$) Paper (on file as ambient trans 2.bmp).
[165] R. Dias Interview (Jun. 9, 2023) 95:8-11, 97:18-98:11.
[166] *See* Email from Respondent to Interviewee 3 (Oct. 23, 2019) (on file as NDG email.pdf) (Email with no subject line and no text in the body, attaching the $MnS_2$ data file named "MnS2.dat").
[167] $MnS_2$ data file (on file as MnS2.dat) (Data sent by Respondent to Interviewee 3 by email on October 23, 2019).
[168] *See* Figure $MnS_2$_2, above.
[169] *See* Figures $MnS_2$_3 and $MnS_2$_4, above.

- Data from "MnS2.dat" do not constitute raw (original) datasets. The Investigation Committee expects that raw R(T) data should have at least four to five columns.[170] For example, the raw data files at 36 and 52 GPa each contain five columns (time, finger temp, sample temp, voltage, and current). To date, Respondent has failed to provide fulsome, raw datasets for the published R(T) curves at 13, 16, and 26 GPa in **Figure 1b** of the PRL 2021 ($MnS_2$) Paper.
- The Investigation Committee's comparison of the data from "MnS2.dat" and the curves obtained by rescaling the $GeSe_4$ data provided by Interviewee 7 to the Investigation Committee (these $GeSe_4$ data were sent via email by Respondent to Interviewee 7 on Mar. 15, 2023) using the mathematical function with four adjustable parameters identified by Anonymous Reviewer Gamma demonstrate that (1) the $MnS_2$ data can be reproduced from the $GeSe_4$ data to the fourth or fifth significant digit across the entire temperature range presented, and (2) that the noise features between the datasets are identical (*i.e.*, the noise features arise from the same measurement and the two curves are scaled versions of the same data).[171]
- The Investigation Committee's analysis of the first differences (or first derivatives) in resistance show distorted digitization (*i.e.*, non-parallel lines in the first differences versus index plot), which indicates that the data have been somehow scaled. When an inverse of the mathematical function discovered by Anonymous Reviewer Gamma is applied to these data, the distorted digitization transforms into digitization one would expect given finite resolution of measuring equipment (*i.e.*, parallel lines in the first differences versus index plot), indicating that these "MnS2.dat" data were indeed mapped as alleged by Anonymous Reviewer Gamma.[172]
- The Investigation Committee's comparison of "MnS2.dat" and the $GeSe_4$ data obtained by the Investigation Committee from Interviewee 7 (files GeSe4_13pt5GPa.csv, GeSe4_16GPa.csv, and. GeSe4_24GPa.csv) demonstrate that the temperature series for corresponding pairs of these data files ($GeSe_4$ at 16 GPa and $MnS_2$ at 26 GPa, $GeSe_4$ at 24 GPa and $MnS_2$ at 16 GPa, and $GeSe_4$ at 13.5 GPa and $MnS_2$ at 13 GPa) are identical over a series of 25,180 data points.[173] This level of agreement can only result if the corresponding data series originated from the same measurement.

Findings/Reasoning:

Respondent's assertion that all R(T) data were measured in Respondent's laboratory at the University is contradicted by the testimony of his former students (Interviewee 3, Interviewee 6, Interviewee 5), all of whom stated that three of the low-temperature resistance curves (at 13, 16, and 26 GPa) were not measured in Respondent's laboratory at the University. The students' statements are corroborated by a lack of raw data for the three low-temperature resistance curves on lab computers. In contrast, raw data files at 36 and 52 GPa were found on Respondent's laboratory computers. Respondent provided the data at 13, 16, and 26 GPa to Interviewee 3 via

[170] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19.
[171] *See* Figure $MnS_2$_1. Email from Respondent to Interviewee 7 (Mar. 15, 2023) (on file as Email from Dias to Salamat (2023-03-15).pdf).
[172] *See* Figure $MnS_2$_5.
[173] *See* Figure $MnS_2$_6.

email, in the form of processed data (not raw data). Respondent has, to date, not provided the raw data files for these measurements, despite repeated requests from the Investigation Committee. Accordingly, the provenance of the 13, 16, and 26 GPa data can be inferred only from analysis of the available data: (1) as published; (2) as sent to Interviewee 3 by Respondent ($MnS_2$ data); and (3) as sent to Interviewee 7 by Respondent ($GeSe_4$).

Analysis by Anonymous Reviewer Gamma from the post-publication review initiated by *PRL* editors indicates that the R(T) data for $MnS_2$ in question can be generated from the $GeSe_4$ data, using a mathematical function with four adjustable parameters. This analysis was confirmed by the Investigation Committee, who were able to reproduce the $MnS_2$ results from the $GeSe_4$ data to the fourth or fifth significant digit across the entire temperature range presented. Furthermore, the noise features between corresponding datasets were found to be identical (*i.e.*, the noise features arise from the same measurement and the two curves are scaled versions of the same data). Finally, the Investigation Committee used the inverse of the mapping discovered by Anonymous Reviewer Gamma to inverse map the data contained in the file named "MnS2.dat" sent to Interviewee 3 by Respondent on October 23, 2019. This inverse mapping transforms the distorted digitization present in the first differences (or first derivative) of resistance to digitization one would expect given finite resolution of measuring equipment. This is clear evidence that the three low-temperature R(T) curves (at 13, 16, and 26 GPa) reported for $MnS_2$ were indeed mapped from the $GeSe_4$ data reported in Respondent's PhD dissertation (several years before Respondent joined the University) and did not originate from an experimental measurement on $MnS_2$.

Conclusion:

The Investigation Committee's findings clearly show that Respondent manipulated from measured data the resistance curves at 13, 16, and 26 GPa reported in the PRL 2021 ($MnS_2$) Paper, most likely the $GeSe_4$ data reported in Respondent's PhD dissertation, and that the published data did not originate from an experimental measurement on $MnS_2$. This manipulation is a blatant and significant departure from accepted practices within the research community, and clearly constitutes intentional data fabrication and/or falsification of the three low-temperature R(T) curves at 13, 16, and 26 GPa.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation B.1** constitutes research misconduct.

### 2. Data provided to the Investigation Committee does not correspond to published data

Context:

During the post-publication review initiated by *PRL* editors, Interviewee 7 was asked—as the corresponding author—to provide copies of the electronic data files used to prepare **Figure 1b** of

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the PRL 2021 ($MnS_2$) Paper. These data were provided to *PRL* roughly four months after the initial request from the editors.[174]

Figure for Reference:

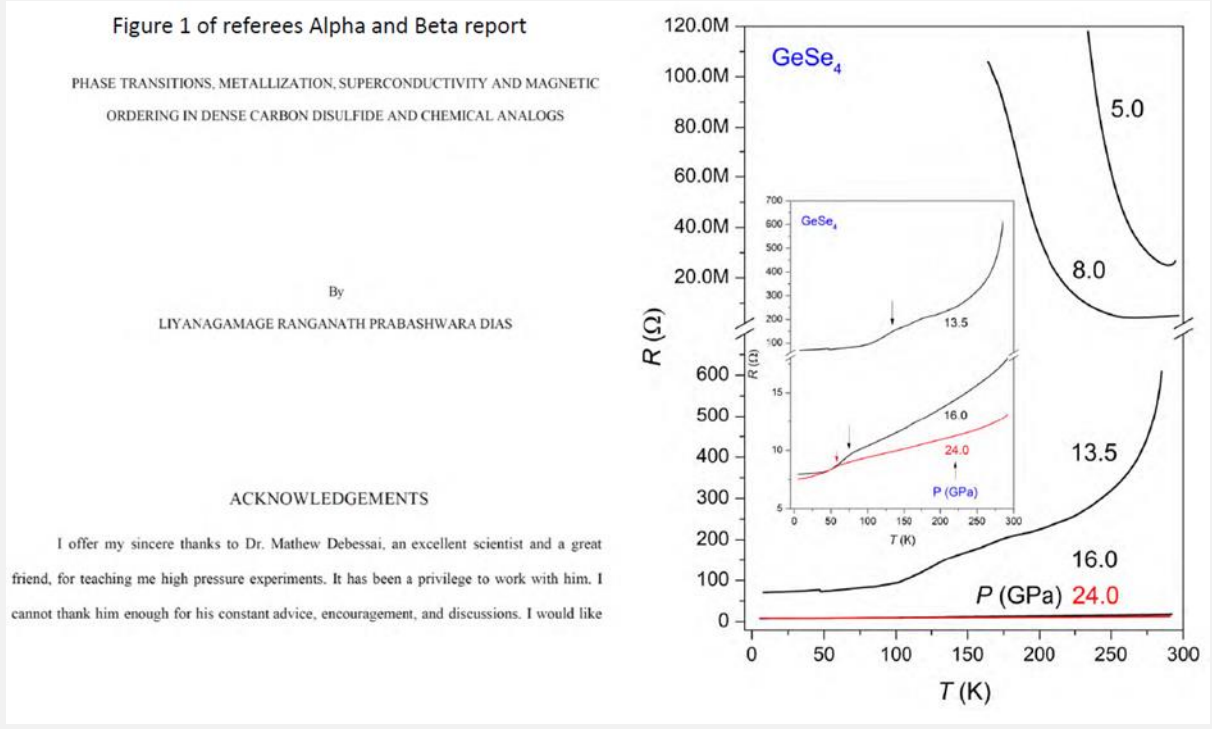


Figure 1 from Report of Anonymous Reviewers Alpha and Beta.[175]

Evidence:

- During the post-publication review initiated by *PRL* editors, all four Anonymous Reviewers (Alpha, Beta, Gamma, and Delta) concluded that the data provided to them by Interviewee 7 do not agree with the data presented in **Figure 1b** of the PRL 2021 ($MnS_2$) Paper.[176] These data were provided to *PRL* by Interviewee 7, as the corresponding author of the paper. However, Interviewee 7's statements during his interview with the Investigation Committee indicate that these data were sent to Interviewee 7 by Respondent after a four-month delay and that Interviewee 7 did not question the authenticity of these data before sending them on to *PRL*.[177] Interviewee 7's statements are corroborated by email exchanges relevant to his

[174] *See* Interviewee 7 Interview (Oct. 2, 2023) 30:11-33:1.
[175] Report of referees Alpha and Beta concerning "Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator $MnS_2$", Physical Review Letters 127, 016401 (2021) (on file as Report Alpha and Beta.pdf).
[176] *Id*.; Independent Report on Dr. Hamlin's Accusations of Data Copying in "Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator $MnS_2$" (PRL 127, 016401, 2021): Report Delta (on file as Report Delta.pdf); Independent comparison of resistance data in PRL 127, 016401 (2021) and in the dissertation of R. P. Dias (2013): Reviewer Gamma (on file as Report Gamma.pdf).
[177] *See* Interviewee 7 Interview (Oct. 2, 2023) 30:11-33:1.

interview statements.[178]

- As noted earlier in this report, on October 23, 2019, Respondent emailed a file named "MnS2.dat" to Interviewee 3. The file consists of six data columns, each containing 25,180 data points. The first and second columns, third and fourth columns, and fifth and sixth columns contained the R(T) data reported for $MnS_2$ at 26, 16, and 13 GPa, respectively.[179]
    - Data from "MnS2.dat" ***do not*** match data provided by Respondent to *PRL* during the post-publication review process or to the Investigation Committee.[180] The data files provided by Respondent contain 11,662, 16,726, and 16,829 data points for the 13, 16, and 26 GPa curves, respectively. However, data from "MnS2.dat" ***do*** match the low-temperature resistance curves extracted by Dr. Hamlin using a vector-based extraction method from **Figure 1b** of the PRL 2021 ($MnS_2$) Paper;[181] in particular, for the 13 GPa trace, both these data and the data extracted from the PRL 2021 ($MnS_2$) Paper exhibit abrupt drops in resistance near 47 and 82 K (these abrupt drops are not present in the data provided by Respondent to *PRL* or the Investigation Committee). This agreement also is evident when comparing an overlay of **Figure 1b** in the PRL 2021 ($MnS_2$) Paper with these data[182] and the data extracted by Dr. Hamlin using a vector-based extraction method from **Figure 1b** of the PRL 2021 ($MnS_2$) Paper.

Findings/Reasoning:

Comparisons of data extracted from **Figure 1b** in the PRL 2021 ($MnS_2$) Paper, data provided to *PRL* by Interviewee 7 (purportedly provided to Interviewee 7 by Respondent), and data provided to the Investigation Committee by Respondent, show that the data provided to *PRL* and to the Investigation Committee are inconsistent with the data presented in **Figure 1b** of the PRL 2021 ($MnS_2$) Paper. Based on the findings/reasonings set forth at **Allegation B.1** above, there is clear evidence that the three low-temperature resistance curves (at 13, 16, and 26 GPa) reported for $MnS_2$ and displayed in **Figure 1b** were indeed mapped from measured data, most likely the $GeSe_4$ data reported in Respondent's PhD dissertation, and did not originate from an experimental measurement on $MnS_2$. Therefore, the Investigation Committee finds that the only logical explanation as to why the files provided to *PRL* (after a four-month delay) and the Investigation Committee differ from those sent to Interviewee 3 by Respondent via email on October 23, 2019, is that Respondent altered the data files provided to *PRL* and to the Investigation Committee to conceal data fabrication and/or falsification.

[178] Email Records of Interviewee 7 (on file as MnS2 email exchange.pdf, and also available in the folder "Email Records of A. Salamat") (Provided by Interviewee 7 to the Investigation Committee); and Email from Interviewee 7 to *PRL* (Jul. 21, 2023) (on file as LB17112 Durkee_My email to PRL after post pub review.pdf).
[179] *See* Email from Respondent to Interviewee 3 (Oct. 23, 2019) (on file as NDG email.pdf) (Email with no subject line and no text in the body, attaching the $MnS_2$ data file named "MnS2.dat"); *see also* MnS2 data file (on file as MnS2.dat) (data sent by Respondent to Interviewee 3 by email on October 23, 2019); *see also* $MnS_2$ data file (on file as MnS2.dat) (Data sent by Respondent to Interviewee 3 by email on Oct. 23, 2019).
[180] *See* Figure $MnS_2$_2.
[181] *See* Figure $MnS_2$_3.
[182] *See* Figure $MnS_2$_4.

Conclusion:

These findings indicate at least one instance of intentional fabrication and at least one instance of intentional falsification for each of the three low temperature R(T) curves in **Figure 1b** (at 13, 16, and 26 GPa): (1) fabrication of the initial R(T) curves as evidenced by the mathematical function with four adjustable parameters (identified during post-publication review) that convincingly maps three high pressure $GeSe_4$ resistance curves (at 13.5, 24, and 16 GPa) reported in Respondent's PhD dissertation to the R(T) curves in question; and (2) falsification of data provided to *PRL* and the Investigation Committee in an attempt to conceal the aforementioned fabrication. Such actions constitute a significant departure from accepted practices of the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation B.2** constitutes research misconduct.

## C. Chem. Commun. 2022 Paper

- **Fabrication and/or falsification of Figure 1a and Figure S13, R(T) data (resistance as a function of temperature)**

Context:

The Chem. Commun. 2022 Paper was submitted on June 5, 2022 and published on July 6, 2022. During this time period, Interviewee 7 and Respondent had been informed by *Nature* editors that the Nature 2020 (CSH) Paper was to be retracted.[183] In the Chem. Commun. 2022 Paper, x-ray diffraction measurements at room temperature and first-principles numerical simulations are combined with electrical resistance measurements as a function of temperature (R(T)), which reveal drops to zero resistance that indicate superconducting behavior in CSH samples synthesized from methane, sulfur, and hydrogen gas (which is different from the method reported in the Nature 2020 (CSH) Paper).

The main claim of the Chem. Commun. 2022 Paper is that superconductivity at high temperature near 200K is observed near 1 Mbar of pressure, a pressure lower than the minimum pressure at which superconductivity was reported in the Nature 2020 (CSH) Paper. Because the electrical resistance measurements are the only evidence to support superconducting behavior of CSH in the Chem. Commun. 2022 Paper, they are essential to the validity of the claim.

[183] Email from Tobias Roedel to Respondent and Interviewee 7 (May. 31, 2023, 3:51pm) (on file as 2022.06.17 Email TR.RD.pdf).

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Figures for Reference:[184]

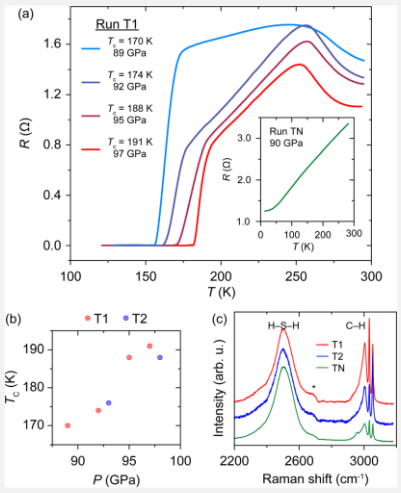



Fig. 1 (a) Resistance response of C–S–H (Run T1) on cooling, displaying a superconducting transition at 191 K at 97 GPa. (Inset) *R* response from Run TN at 90 GPa showing metallic behavior. (b) Evolution of $T_c$ with *P* for Runs T1 and T2. (c) Comparative Raman spectra of Runs T1 and T2, and Run TN at 4.0 GPa and 300 K. The feature marked with an asterisk (*) is second-order Raman scattering from diamond.

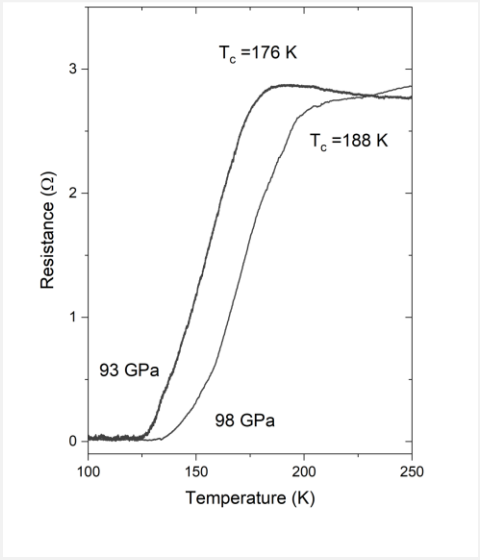
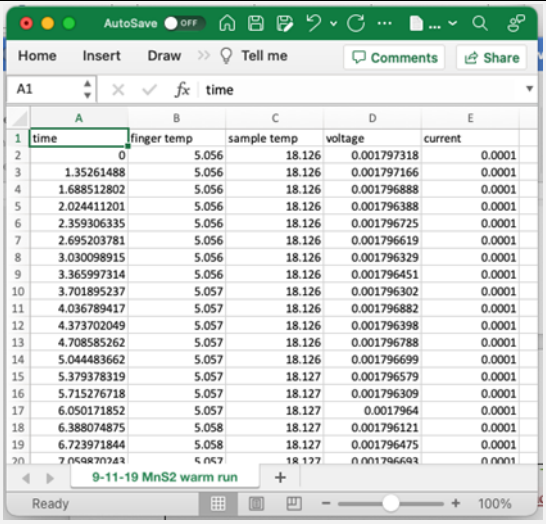



Figure S13: Resistance response with temperatures for run 2 of the transport data

**Left:** Figure 1 from the Chem. Commun. 2022 Paper. The R(T) curves are in Figure 1a (Top). **Right:** Figure S13 from the supplementary materials of the Chem. Commun. 2022 Paper.



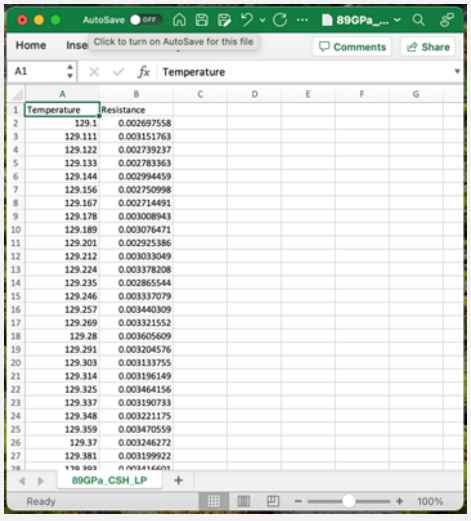




**Figure CC_1: Left:** Example of a raw data file when collecting R(T) data using a DC current source. This data file, "9-11-19 MsS2 warm run.csv",[185] was collected by Interviewee 5, Interviewee 3, Interviewee 8, and another student during measurement of a $MnS_2$ sample using the measurement setup established in Respondent's lab (data retrieved from sequestered hard drive). **Right:** Data file provided by Respondent, "89GPa CSH LP.csv"[186] for one of the curves in **Figure 1a**; other data files provided by Respondent have the same structure with only two columns containing a *temperature* and a *resistance* series.

[184] See file containing python code for generating the plots in figures CSH_2-5 (on file as RvsT data CSH#2.pdf).
[185] *See* Sequestered warm run raw data 9-11-19 (on file as 9-11-19 MnS2 warm run.csv).
[186] *See* 89 GPa CSH low pressure data file (on file as 89GPa_CSH_LP.csv) (Provided by Respondent to Investigation Committee).

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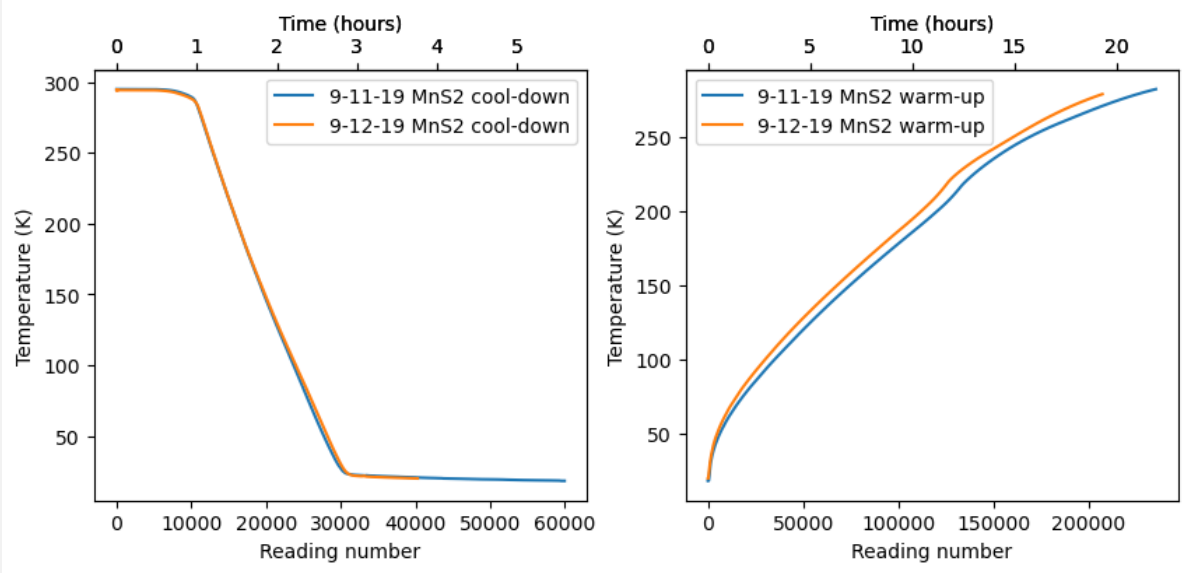


**Figure CC_2: Left:** Example of two cool-down curves[187] when collecting R(T) data. **Right:** Example of two warm-up curves[188] when collecting R(T) data (measurements of $MnS_2$ by Interviewee 5, Interviewee 3, Interviewee 8, and another student, data retrieved from sequestered hard drive). Note the similarity of repeat measurements conducted with the same experimental protocol, but on different days.

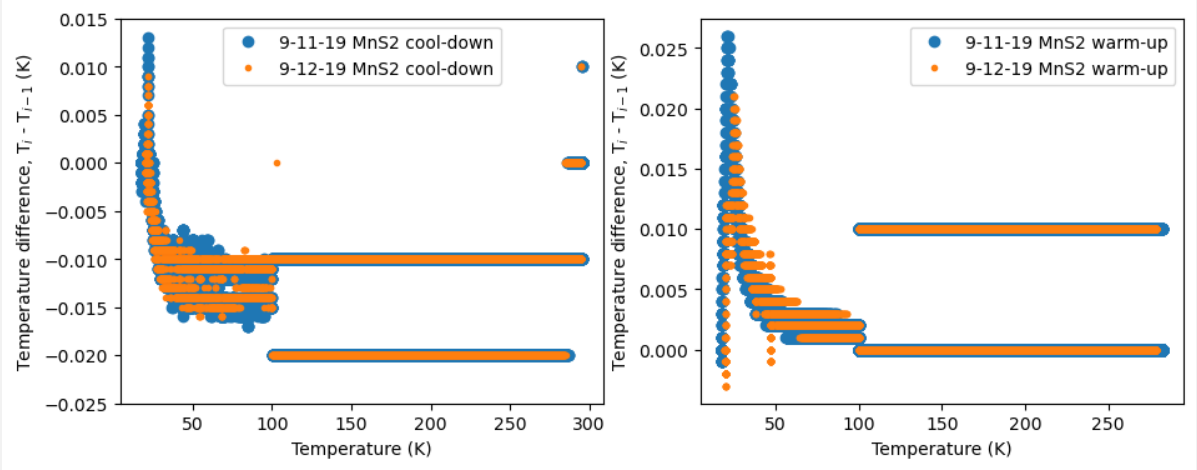


**Figure CC_3: Left:** Example of typical temperature differences between sequential readings during cool-down (note negative sign).[189] **Right:** Example of typical temperature differences during warm-up.[190] The jumps between readings show that the data are digitized at ±0.001 K increments for T < 100 K and at ±0.01K increments at T > 100 K (*i.e.*, five significant digits). Same data as in Figure CC_2, above.

[187] *See, e.g.*, Sequestered cryo run raw data 9-11-19 (on file as 9-11-19 MnS2 cryo run.csv); Sequestered cryo run raw data 9-12-19 (on file as 9-12-19 MnS2 cryo run.csv).
[188] Sequestered warm run raw data 9-11-19 (on file as 9-11-19 MnS2 warm run.csv); Sequestered warm run raw data 9-12-19 (on file as 9-12-19 MnS2 warm run.csv).
[189] Sequestered cryo run raw data 9-11-19 (on file as 9-11-19 MnS2 cryo run.csv); Sequestered cryo run raw data 9-12-19 (on file as 9-12-19 MnS2 cryo run.csv).
[190] Sequestered warm run raw data 9-11-19 (on file as 9-11-19 MnS2 warm run.csv); Sequestered warm run raw data 9-12-19 (on file as 9-12-19 MnS2 warm run.csv).

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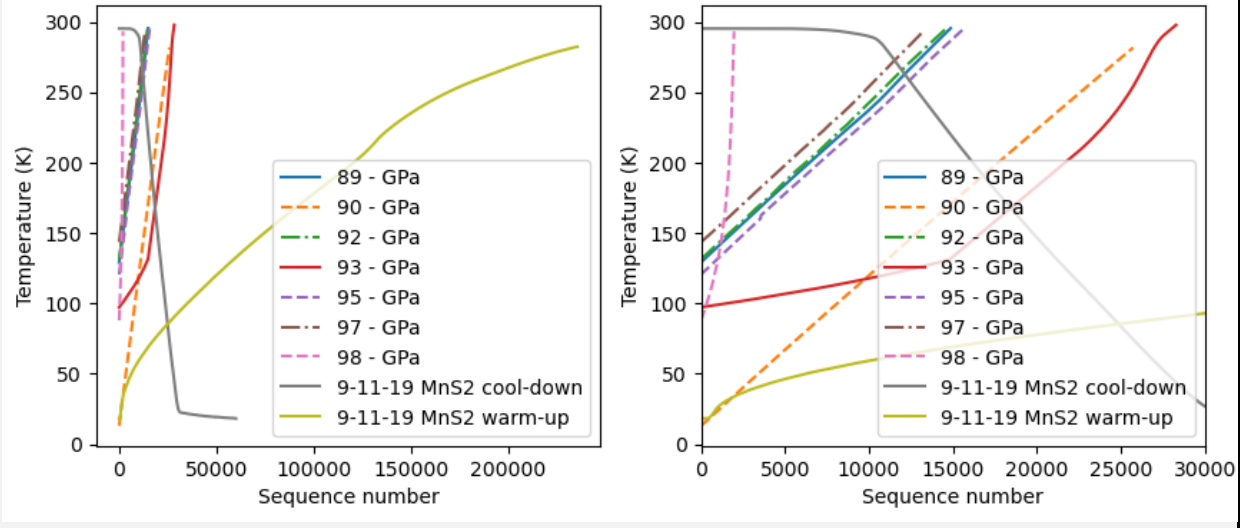


**Figure CC_4: Left:** Temperature versus reading number for the data provided by Respondent[191] compared with the $MnS_2$ data collected by the students (a representative typical case).[192] **Right:** Same data replotted on truncated x axis. ***Several anomalies are noted*:** (1) during cool-down, the temperature should decrease with sequence number contrary to the data supplied by Respondent (Respondent stated the measurements were done during cool-down in Figure 1 caption); (2) the rate of temperature change with sequence number is much higher in the 98 GPa case and much lower in the 93 GPa case than the other cases; (3) none of the data show the change in slope near room temperature (295 K) that is typical of a cooling experiment (a behavior similar to the $MnS_2$ cool-down record between 5000 and 15000 readings is expected).

[191] *See* CSH low pressure data files (on file as 89GPa_CSH_LP.csv, 90GPa_CSH_LP.csv, 92GPa_CSH_LP.csv, 93GPa_CSH_LP.csv, 95GPa_CSH_LP.csv, 97GPa_CSH_LP.csv, 98GPa_CSH_LP.csv) (Provided by Respondent to the Investigation Committee).
[192] Sequestered cryo run raw data 9-11-19 (on file as 9-11-19 MnS2 cryo run.csv); Sequestered warm run raw data 9-11-19 (on file as 9-11-19 MnS2 warm run.csv).

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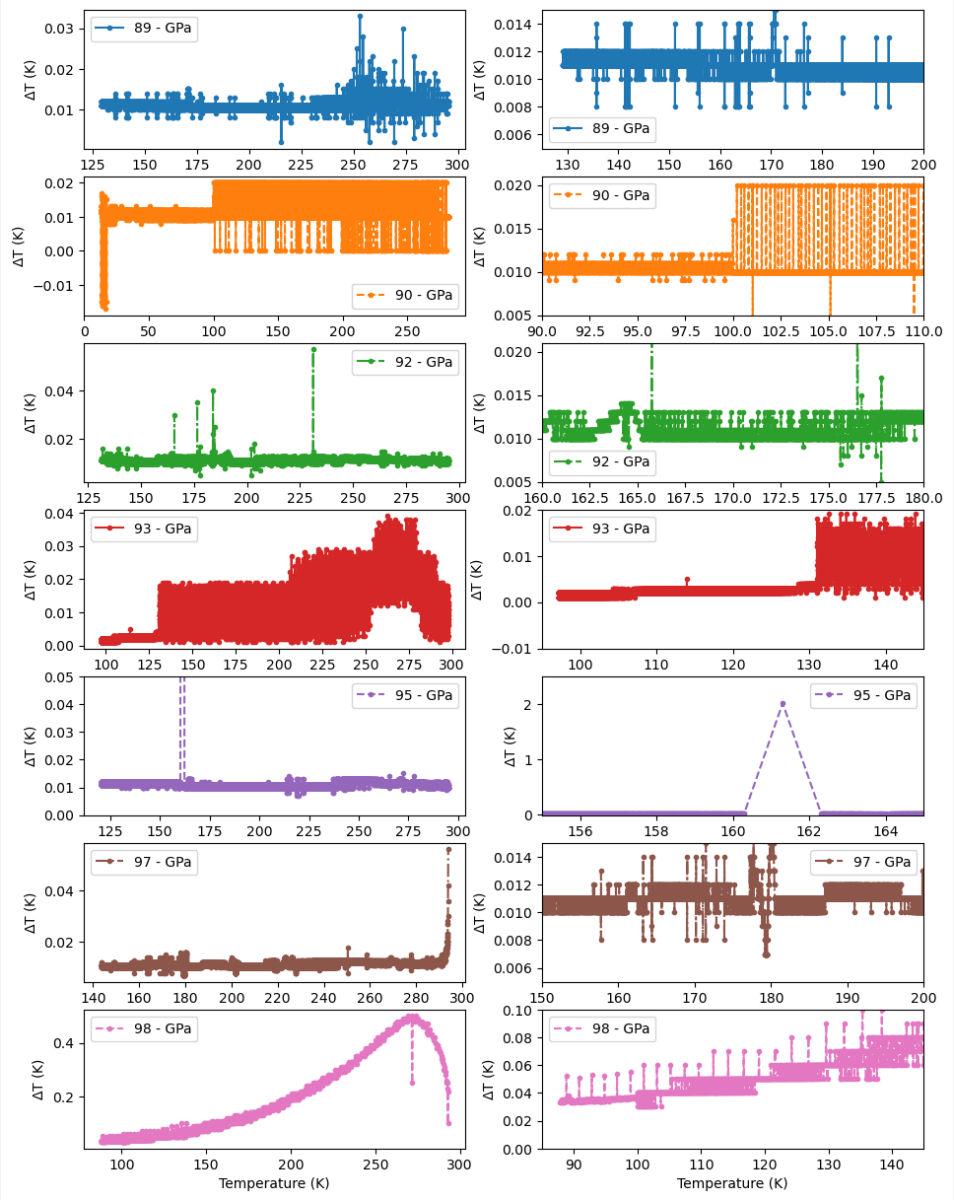


**Figure CC_5**: **Left:** Temperature difference between sequential temperature readings, $\Delta T = (T_i - T_{i-1})$, as a function of temperature for the seven datasets provided by Respondent.[193] All except one (labeled "**90 GPa**") show features that are not typical of the measurement setup in place at Respondent's lab. For comparison, see Figure CC_3**,** above, for expected behavior. **Right:** Same data displayed on expanded scales to reveal anomalies. These are: **89 GPa** digitization increment ±0.001 K above 100 K where ±0.01 K is expected; **90 GPa** no evident anomalies; **92 GPa** digitization increment ±0.001 K above 100 K where ±0.01 K is expected and systematic anomaly near 164 K; **93 GPa** digitization increment ±0.001 K above 100 K where ±0.01 K is expected followed by digitization levels > ±0.01 K incommensurate with known instrument digitization; **95 GPa** digitization increment ±0.001 K above 100 K where ±0.01 K is expected and 2 K gap in data from 160.297 K to 162.309 K; **97 GPa** digitization increment ±0.001 K above 100 K where ±0.01 K is expected and anomalous systematic variation in DT near 180 K; **98 GPa** multiple instances where digitization increment ±0.01 K below 100 K where ±0.001 K is expected, digitization increment ±0.001 K above 100 K where ±0.01 K is expected and overall trend very different from all other data.

[193] *See* CSH low pressure data files (on file as 89GPa_CSH_LP.csv, 90GPa_CSH_LP.csv, 92GPa_CSH_LP.csv, 93GPa_CSH_LP.csv, 95GPa_CSH_LP.csv, 97GPa_CSH_LP.csv, 98GPa_CSH_LP.csv) (Provided by Respondent to the Investigation Committee).

Evidence:

- The corresponding author on this paper is Interviewee 7 and the publication date is July 6, 2022, a date when Respondent's laboratory had the capability to collect R(T) data, but Interviewee 7's laboratory did not.[194]
- Interviewee 8 testified to the Investigation Committee that he thought that the R(T) measurement was performed at UNLV, but that he had no direct knowledge of the measurement and he was unaware of any such measurements carried out in Respondent's laboratory.[195] Conversely, Interviewee 7 thought that the R(T) data were measured at Respondent's laboratory. Through later (post-publication) conversations with former students of Respondent's laboratory, Interviewee 7 discovered that the R(T) data did not originate from measurements at Respondent's lab. Based on the uncertain origin of the R(T) data, during interview with the Investigation Committee, Interviewee 7 noted that he was considering requesting a retraction with the journal.[196] Subsequently, the Chem. Commun. 2022 Paper was retracted on January 15, 2024.[197]
- Despite a specific request,[198] Respondent failed to provide to the Investigation Committee a fulsome, raw dataset for published R(T) curves in **Figure 1a** and **Figure S13**—and instead provided only warming curves with two data columns spanning a small, truncated subset of temperatures.
    - Based on its discussions with former members of Respondent's laboratory, the Investigation Committee expects that raw R(T) data should have at least four to five columns[199] and should span the full range of temperatures from cryogenic (~10 K) to room temperature (300 K).[200]
    - The Investigation Committee was unable to find within sequestered materials, including sequestered hard drives from Respondent's laboratory, any raw data files corresponding

[194] *See* Interviewee 7 Interview (Oct. 2, 2023) 7:2-8:17.
[195] *See* Interviewee 8 Interview (Jul. 20, 2023) 35:11-24.
[196] *See* Interviewee 7 Interview (Oct. 2, 2023) 48:20-51:1.
[197] The retraction notice includes the following statement:

> We, the named authors, hereby wholly retract this Chemical Communications article based on our concerns over the origins of the electrical transport measurements presented. While the validity of the X-ray crystallographic study and structure calculations of carbonaceous sulfur hydride (C–S–H) are maintained, we have lost confidence in the origin of the electrical transport measurements, and therefore all conclusions deduced from the electric measurements, including the superconductivity properties are uncertain. Therefore, this article is being retracted to avoid misleading readers and to protect the accuracy and integrity of the scientific record. We regret any confusion or inconvenience caused to the scientific community.

The retraction notice further states that Respondent was contacted but did not respond. *See* G. Alexander Smith, Ines E. Collings, Elliot Snider, Dean Smith, Sylvain Petitgirard, Jesse S. Smith, Melanie White, Elyse Jones, Paul Ellison, Keith V. Lawler, Ranga P. Dias & Ashkan Salamat, *RETRACTED ARTICLE: Carbon content drives high temperature superconductivity in a carbonaceous sulfur hydride below 100 GPa*, CHEMICAL COMMUNICATIONS 58, 9064 (2022), https://doi.org/10.1039/D3CC90410E.
[198] NSF – University of Rochester Investigation Request for Materials from Dr Ranga Dias (May 22, 2023), in Exhibit H (Investigation Committee's first request to Respondent for materials).
[199] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19.
[200] *See* Figure CC_1, above.

to the CSH data published in the Chem. Commun. 2022 Paper. However, if such data were collected with the equipment in Respondent's laboratory, the temperature series of such data predictably would have similarities to the temperature series of the raw datasets measured with other samples. The Investigation Committee did obtain, through sequestered computer hard drives in Respondent's laboratory, the original data files created during $MnS_2$ R(T) measurements carried out in Respondent's lab in September 2019. These $MnS_2$ files provide examples of typical R(T) raw data files collected in Respondent's lab.[201] Features of these raw data files include:

- A timestamp for every reading, two temperature readings, voltage reading, and current reading.[202]
- Near-uniform sampling rate at three samples per second (0.335 s sampling period for the $MnS_2$ data).
- Measurements on both cool-down (three to five hours duration, approximately 50,000 readings) and warm-up (12 to 20 hours duration, approximately 200,000 readings).[203]
- Resolution of temperature readings (digitization increment) is ±0.001 K below 100 K and ±0.01 K above 100 K (*i.e.*, five significant digits), a characteristic of the temperature sensor and controller instrument deployed in Respondent's laboratory.[204]
- During warm-up, the temperature rise shows a typical pattern of variability with rate of rise much faster than the average rate below 50 K and slower than the average rate above 250 K.

- Many features of the datasets provided by Respondent do not follow the patterns typical of the raw datasets, including the datasets identified by the Investigation Committee via its sequestration processes and described above. Anomalous features of the datasets provided by Respondent include:
  - No timestamps, and thereby no way to discern whether the data were collected during cool-down or warm-up (however, the provided data had increasing temperature with series index indicating a warm-up measurement). The caption on **Figure 1** states that run T1 was measured during cooling, but Respondent also has indicated in other communications that cool-down measurements usually are not recorded.[205] Without the

[201] *See, e.g.*, Sequestered warm run raw data 9-12-19 (on file as 9-12-19 MnS2 warm run.csv); Sequestered cryo run raw data 9-11-19 (on file as 9-11-19 MnS2 cryo run.csv). Both documents were found under a folder named 9-10-19 Salamat MnS2, and within the subfolder 9-12-19.
[202] *See* Figure CC_1, above.
[203] *See* Figure CC_2, above.
[204] *See* Figure CC_3, above.
[205] Email from Respondent to Stephen Dewhurst (Jun. 8, 2023, 10:26:06am EDT), in Exhibit H ("Regarding the requested 'cooling data,' I want to inform you that we do not possess cooling data for the specific measurements in question. Generally, we do not collect data during the cooling process due to its fast nature and increase in pressure during cooling, which often fails to accurately represent the properties of the materials under study. Consequently, we do not have any cooling data to provide to the Investigation Committee."). *See* Third Rebuttal for Nature 2023 (LuH) Paper (on file as Dias_2023_peer_review_3rd_rebuttal.pdf) (Provided by Nature to Investigation Committee) ("We do [a] lot of testing during fast cooling and do not collect data. We always collect data while warming up.").

raw data, it is not possible to definitively determine whether the data were captured during cool-down or warm-up.

- Data file sizes range from 1,963 readings to 28,277 readings, smaller than the 50,000 readings expected during cool-down.
- Datasets were truncated at temperatures near 100 K in all cases except one.[206]
- Notable differences in the slope and the curvature near room temperature (295 K) compared to a typical cool-down experiment.
- Temperature differences show behavior very different from expected digitization (±0.001 K below 100 K and ±0.01 K above 100 K) on all datasets except the 90 GPa dataset; the 90 GPa curve (sample "TN" in the article, **Figure 1a** inset) is the only one that did ***not*** show evidence of superconductivity. When the Investigation Committee asked Respondent about temperature measurements, Respondent responded vaguely, without providing details.[207]
- Analysis of the temperature series in these measurements reveals several anomalies and features incompatible with the measurement set-up in place at Respondent's laboratory prior to publication of this work.[208]

Findings/Reasoning:

Interviewee 8 stated to the Investigation Committee that Respondent had told him that the data at issue were measured at UNLV; but at that time UNLV did not have the capability to perform such measurements. Interviewee 7 stated that he thought the data were measured by the students working in Respondent's laboratory. Accordingly, it appears that Respondent mislead his co-authors as to the provenance of the R(T) data. The R(T) data, as published, were provided to the Investigation Committee by Respondent, but not in raw form as requested. The data provided by Respondent to the Investigation Committee show multiple anomalies in the temperature series that are atypical of the measurement technique, indicating that the data have been fabricated and/or falsified. Despite several requests from the Investigation Committee for the raw data files for the measurements in question, Respondent has failed to provide these files during the course of this proceeding, strongly indicating to the Investigation Committee such raw data files may not exist.

Conclusion:

Respondent, as the sole source of the published R(T) data, provided an explanation to his students as to the provenance of the data (measured at UNLV) that was different from the explanation given to his UNLV colleagues (measured in Respondent's lab), thereby showing an intent to mislead both groups. Furthermore, the data provided by Respondent show multiple anomalies in the temperature series that are atypical of the measurement technique. Taken together, these multiple inconsistencies indicate intentional data fabrication and/or falsification of the R(T) data published in the Chem. Commun. 2022 Paper and provided to the Investigation

[206] *See* Figure CC_4.
[207] *See* R. Dias Interview (Jul. 14, 2023) 109:7-110:25.
[208] *See* Figures CC_4 and CC_5.

Committee. This represents a significant departure from accepted practices within the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation C** constitutes research misconduct.

### D. Nature 2023 (LuH) Paper

The Nature 2023 (LuH) Paper reports an extraordinary finding—namely, the observation of superconductivity at room temperature at pressures near 10 kbar. In contrast with the CSH claim for superconductivity in the 1-3 Mbar range, 10 kbar pressures can be routinely achievable at the industrial scale.

Taken at face value, this paper presents a particularly strong case to the reader, with a combination of the most common measurement techniques (including, in particular, magnetic measurements using the standard PPMS measurement system), all revealing convincing signatures for superconductivity at similar temperature-pressure conditions.

This paper initially was submitted to *Nature* on April 26, 2022, was accepted on January 18, 2023, and was published on March 8, 2023. In a document transmitted to *Nature*, dated May 2, 2023, "Anonymous authors" expressed concerns that "cast serious doubts" on the electrical resistance measurements reported in the paper.[209] This was followed by a reply from Respondent, dated May 28, 2023,[210] and a rebuttal of that reply by the "Anonymous authors" dated June 26, 2023.[211]

A post-publication review was initiated by *Nature* on July 25, 2023, involving four reviewers.[212] On September 8, 2023, a letter was sent to *Nature* by several co-authors of Respondent, expressing serious concerns about the paper.[213] On September 1, 2023, an Editorial Expression of Concern was published, followed by a retraction on November 7, 2023.

The following evidence indicates that Respondent was responsible for preparing the figures and the manuscript associated with the Nature 2023 (LuH) Paper:

- Respondent is the last and corresponding author.

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[209] Anonymous authors, *Issues related to Nature volume 615, 244 (2023)* (May 2, 2023) (on file as Lu_H_N_Concern_original_version.pdf) (Expressing concerns that were raised with Nature Editors).
[210] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[211] Anonymous authors, *Response to author's rebuttal concerning issues in Nature 615, 244 (2023)* (Jun. 26, 2023) (on file as Lu_H_N_Concern_revised_version.pdf).
[212] *See* Email from Tobias Roedel to Respondent and Other Co-Authors (Aug. 31, 2023, 2:50am) (on file as Post-publication peer review process on Nature 615, 244–250 (2023).pdf); *see also* Review report of post-publication reviewer 3 (on file as LuHN_post_publication_reviewer_3.pdf); Review report of post-publication reviewer 4 (on file as LuHN_post_publication_reviewer_4.pdf).
[213] Letter from Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5, Interviewee 4, Keith V. Lawler & Interviewee 7 to Tobias Roedel (Sep. 8, 2023) (on file as Letter to Nature 09-08-2023 Final.pdf); Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug 31, 2023) (on file as LuH-N-concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023).

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- The author contribution statement for the Nature 2023 (LuH) Paper states "N.D.-G., K.V.L., A.S., S.E.D. and R.P.D. [Respondent] wrote the paper."
- Multiple testimonies of Respondent's co-authors indicate that Respondent assembled the data and prepared the figures and manuscript for the paper.[214]
- Several emails and Slack messages provided by Respondent's co-authors indicate that Respondent prepared the Nature 2023 (LuH) Paper, manuscript and figures, and that Respondent provided his co-authors fewer than two days to offer input prior to Respondent submitting the manuscript to *Nature*.[215, 216, 217, 218]
- Screenshots of the *Nature* submission portal, as communicated by Interviewee 4 to the Investigation Committee, confirm the submission timeline implied by the aforementioned testimonies, emails, and Slack messages. Furthermore, the submission portal indicates that on

[214] *See* Interviewee 7 Interview (Oct. 2, 2023) 42:14-42:21 (noting that "[i]t was predominantly Keith and I writing it with Ranga," and when questioned regarding whether group discussions had been held with all co-authors to discuss the LuH data and manuscript, he replied, "No. Never. Never once."); Interviewee 5 Interview (Jul. 20, 2023) 33:24-35:23 (noting that he "didn't agree with . . . data collection being put on the grad students and the interpretation being left solely to Ranga"; that, "[i]n fact, a lot of us didn't even agree with submitting the manuscript on . . . lutetium hydride last year"; and that "we were completely left out of [the publication process]."); Interviewee 9 Interview (Jul. 31, 2023) 17:22-18:6, 19:21-20:8 (when asked who took the lead in preparing the paper, he said that "[Respondent] wrote . . . all the things in there"; that "we never had a group meeting during the redmatter paper" but rather had "one-to-one meetings [with Respondent] to discuss about our results"; and that "[Respondent] had all the explanations why he did that, why he [] added that data, and why he shows this data. And [Respondent] had all the explanations to use. And [Respondent] said he—I mean, his—it is his decision to make. So we had some questions about the figures. And then, [Respondent] took the final decision to [inaudible] we're going to submit to *Nature*."); Interviewee 3 Interview (Jul. 20, 2023) 28:5-16 (when asked whether he prepared the figure for the paper, he replied, "for the ones that are in the papers, . . . [Respondent] prepared the figures that are in the paper"); Interviewee 6 Interview (Jul. 20, 2023) 27:2-13 ("at one point [Respondent] sent us a paper at 2:00 in the morning, and he asked us to get him comments by 10:00 in the morning. And then, he made some changes based on our comments. But we were all upset with the way that things were done. And then, a few days after that, submitting the paper. And we didn't have much input on it.").

[215] A written summary of events provided to the Investigation Committee by Interviewee 6 reveals that the manuscript was not communicated by Respondent to the co-authors until 45 hours prior to submission, and that the figures were not communicated by Respondent to the co-authors until 26 hours prior to submission. *See* Interviewee 6's Timeline of Events (on file as 1.0) 2022.04.25-04.30, Description of Timeline of Red Matter Sub_164238_1.pdf) (Provided from Interviewee 6 to the Investigation Committee).

[216] Interviewee 6's summary of events is corroborated by additional documents, including the copy of an email from Interviewee 3 to Respondent and other co-authors, in which the author notes: "It is difficult to give a full review without the figures." *See* Email From Interviewee 3 to Interviewee 5, Interviewee 8, Interviewee 9 & Interviewee 6 (Apr. 25, 2022, 8:25am) (on file as 1.1) 2022.04.25, 2_09 AM Email from Respondent _ Re_ ReddMatter Request _164237_1.pdf).

[217] An email from Respondent to a subset of the co-authors reads: "Please find attached RM paper. Keep it confidential. I am still finalizing figures. Do not update the actual materials name in the manuscript. Please send me your comments by 10.30 AM today. I am submitting it today." Email from Respondent to Interviewee 3, Interviewee 5, Interviewee 8, Interviewee 9 & Interviewee 6 (Apr. 25, 2022, 2:09am) (on file as 1.2) 2022.04.25, 2_09 AM Email from Respondent _ Re_ ReddMatter Request _164236_1.pdf).

[218] Slack correspondence provides additional evidence. Interviewee 3 asks, "Can we see the figures? It is very difficult to evaluate without them." Respondent replies, "I still have to finalize the figures" and "I am still working on the figures." Interviewee 5 reveals the lack of a group discussion on the content of the paper prior to submission. *See* Slack correspondence between Respondent, Interviewee 5 and Interviewee 3 (Apr. 25, 2022) (on file as 2.1) 2022.04.25, Slack Messages from Respondent to Group (1 of 2) Regard_164232_1.pdf).

April 25, 2022, Respondent already had received *Nature*'s editorial decision on a Pre-Submission Inquiry that had been submitted by Respondent on April 17, 2022.[219]

- Respondent was listed as sole inventor (as Liyanagamage R. Dias) on Patent PCT/US2022/038408 (filed on August 6, 2021),[220] the content of which overlaps significantly with the Nature 2023 (LuH) Paper (received by *Nature* on April 26, 2022) and includes drawings similar to **Figures 1a, 1b, 2a, 3b, and 4** of the Nature 2023 (LuH) Paper.

### 1. Falsification and/or fabrication of Figure 2a, R(T) data (resistance as a function of temperature)

Context:

A key property of superconducting materials is to exhibit zero electrical resistance at temperatures below the critical temperature ($T_c$), which corresponds to the temperature at which—upon warming—the material recovers *normal*, finite electrical resistance. It is, therefore, required for any claim of superconducting behavior to report the temperature dependence of the resistance (R(T)).

**Figure 2a** in the Nature 2023 (LuH) Paper, displayed below, and the data presented therein provide compelling evidence (if taken at face value) to support the claim that LuH exhibits superconductivity at room temperature near 10 kbar.

Figures and Data Tables for Reference:

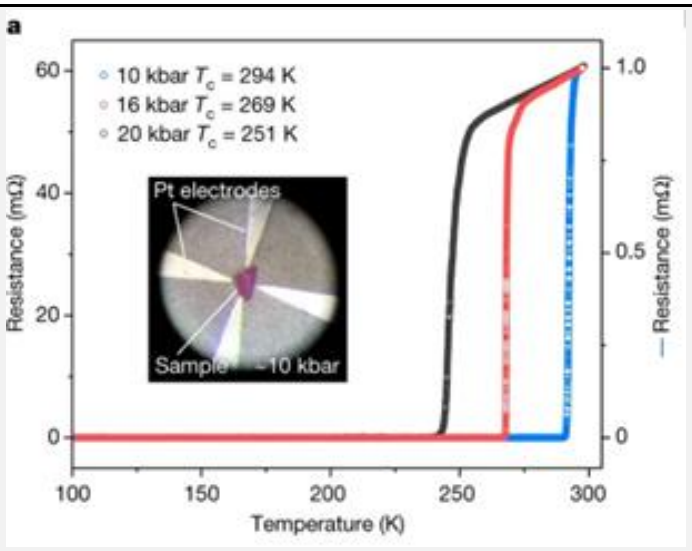


Figure 2a from Nature 2023 (LuH) Paper.

[219] Nature Manuscript Tracking System, Manuscript #: 2022-04-05963 (on file as 2022-04-05963.pdf) (Record of initial submission form to *Nature*, including mention of the synthesis of LuH).
[220] *See* "Height Temperature and low pressure superconductor," PCT/US2022/038408 at Section II.B.

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| Datasets | Method obtained by Investigation Committee | Path or archive location | Filename |
|---|---|---|---|
| **Published data** | Provided by Respondent | ReddMatter Data.zip | Fig.2 and EDF12_Resistance data.csv |
| **Zenodo** | Zenodo public repository https://zenodo.org/records/7374510 | ReddMatter Data.zip | Fig.2 and EDF12_Resistance data.csv |
| **Nature Source File** | Nature public website https://www.nature.com/articles/s41586-023-05742-0#Sec20 | Source Data Fig. 2 | 41586_2023_5742_MOESM6_ESM.xlsx |
| **Co-author data (10 kbar)** | Provided by Co-authors | N/A | Fig2a 10kbar ORD.csv |
| **Co-author data (16 kbar)** | Provided by Co-authors | N/A | Fig2a 16kbar ORD.csv |
| **Co-author data (20 kbar)** | Provided by Co-authors | N/A | Fig2a 20kbar ORD.csv |
| **Sequestered data (10 kbar)** | Sequestered hard drive of computer in Respondent's Laboratory | red matter/8-4-21/ | fullwarmup.csv |
| **Sequestered data (16 kbar)** | Sequestered hard drive of computer in Respondent's Laboratory | red matter/8-5-21/ | warmto180K.csv |
| **Sequestered data (20 kbar)** | Sequestered hard drive of computer in Respondent's Laboratory | red matter/8-8-21/ | warmup 8-8-21.csv |
| **Additional Sequestered data (10 kbar cooling)** | Sequestered hard drive of computer in Respondent's Laboratory | red matter/8-4-21/ | 2.3GPa_RM_lock-in_cooldown.csv |

**Table LuH_1:** Summary of data files for Figure 2a of the Nature 2023 (LuH) Paper.

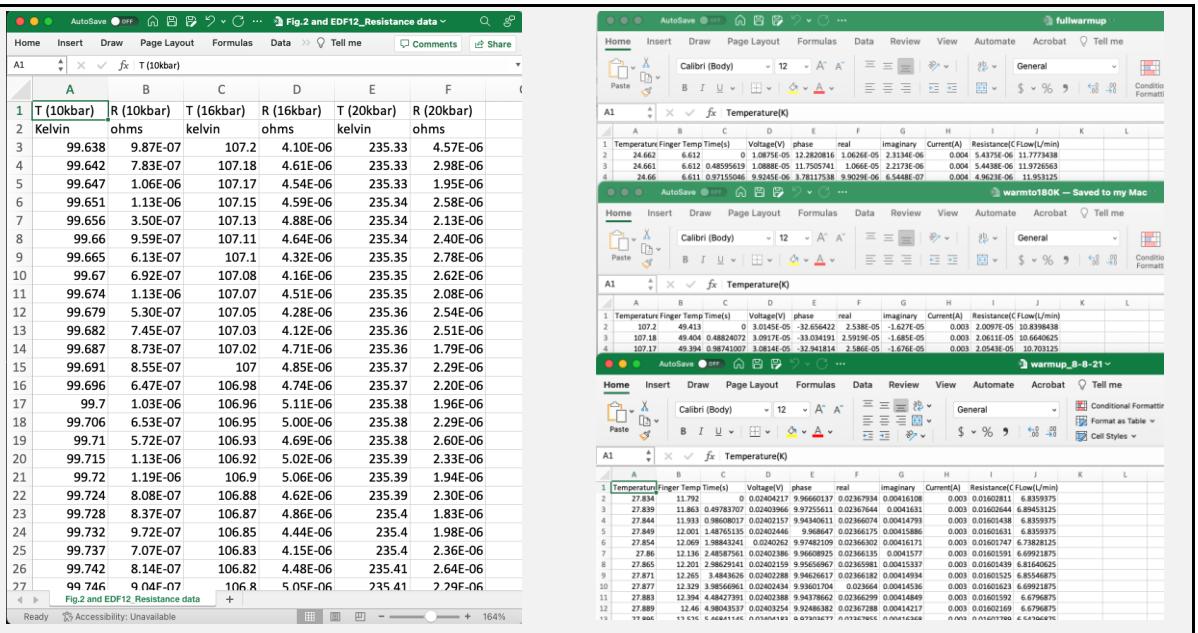


**Figure LuH_1: Comparison of the data file structure relative to the Resistance versus temperature R(T) curves in Figure 2a of the Nature 2023 (LuH) Paper (see Table LuH_1). Left:** Screenshot of the file containing the published data provided to the Investigation Committee by Respondent. This file is identical to the data file on the Zenodo repository and contains the same data as the *Fig.2_Resistance data* tab in the *Nature* source data file.[221] **Right**: Screenshot of the Sequestered data files which appear to be the raw data files. Inspection of the raw data file structure reveals multiple columns including "Time series." In contrast, the published data files only contain two columns (T and R) for each measurement at a given pressure.

[221] *See* summary of data files in Table LuH_1, above.

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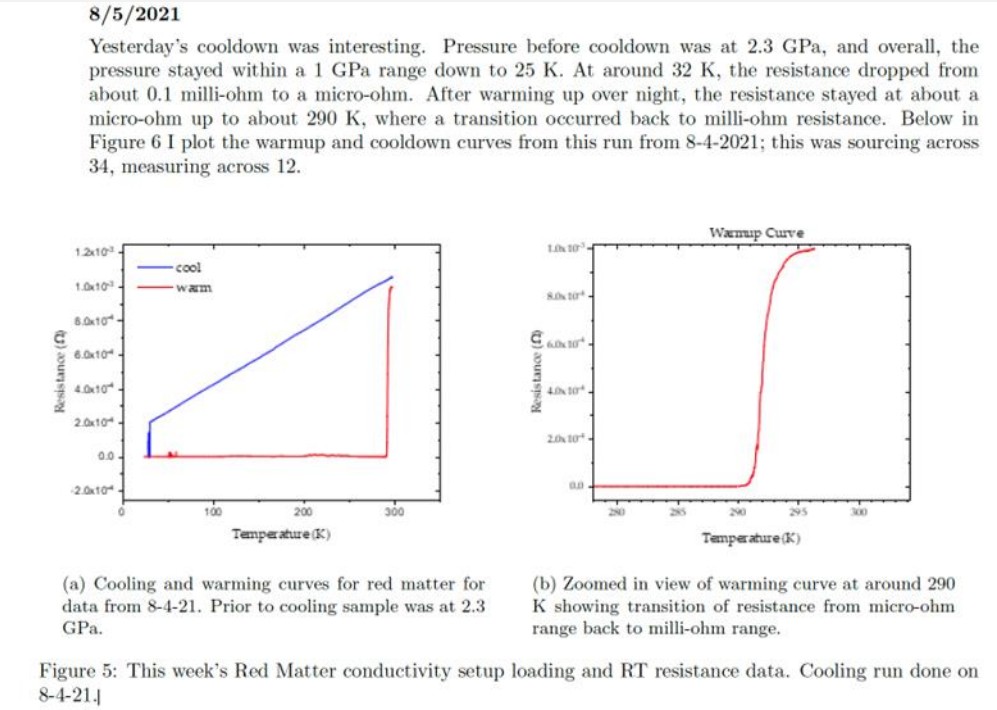

**8/5/2021**

Yesterday's cooldown was interesting. Pressure before cooldown was at 2.3 GPa, and overall, the pressure stayed within a 1 GPa range down to 25 K. At around 32 K, the resistance dropped from about 0.1 milli-ohm to a micro-ohm. After warming up over night, the resistance stayed at about a micro-ohm up to about 290 K, where a transition occurred back to milli-ohm resistance. Below in Figure 6 I plot the warmup and cooldown curves from this run from 8-4-2021; this was sourcing across 34, measuring across 12.



(a) Cooling and warming curves for red matter for data from 8-4-21. Prior to cooling sample was at 2.3 GPa.

(b) Zoomed in view of warming curve at around 290 K showing transition of resistance from micro-ohm range back to milli-ohm range.

Figure 5: This week's Red Matter conductivity setup loading and RT resistance data. Cooling run done on 8-4-21.

**Figure LuH_2:** Excerpt from pages 4-6 in DD_RedmatterNotes_2021-2022.pdf, which contain notes provided by Interviewee 5 to the Investigation Committee.[222] These notes describe the observation of sudden changes in resistance upon cooling and warming of a LuH sample. These measurements were the origin of the data used to produce the 10 kbar curve in Figure 2a of the Nature 2023 (LuH) Paper.

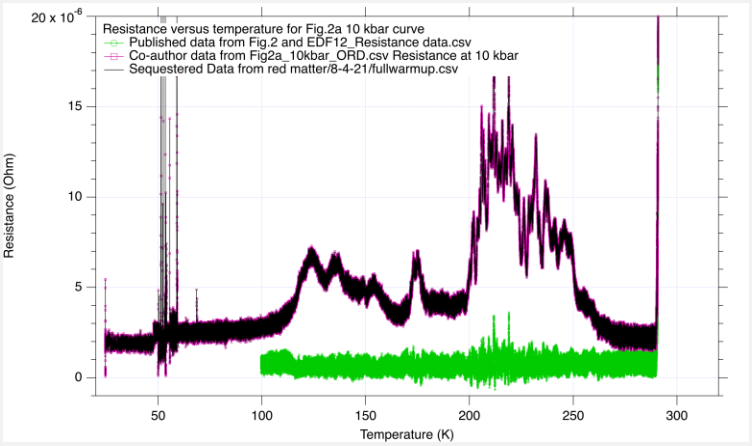


**Figure LuH_3: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 10 kbar in Figure 2a of the Nature 2023 (LuH) Paper: Green:** Data contained in the files provided by Respondent to the Investigation Committee, later referred to as "the published data"; **Magenta**: Data contained in the files provided to the Investigation Committee by the co-authors, later referred to as "the co-author data"; **Black:** Data contained in the files obtained by the Investigation Committee from the sequestered hard drives from Respondent's laboratory, later referred to as "the sequestered data." This figure shows R(T) over the full temperature range but truncates the Resistance axis at 30 micro-Ohm. The co-author data (magenta) and sequestered data (black) appear indistinguishable. In contrast, the published data (green) appear to have been altered to simulate the expected zero resistance of a superconducting sample below ~290K: subtraction of a large fraction of the signal between 100 K and 290K and omission of data below 100 K.

[222] Interviewee 5, *Redmatter Project (2021-2022)* (on file as DD_RedmatterNotes_2021-2022.pdf) (Notes provided by Interviewee 5 to the Investigation Committee).

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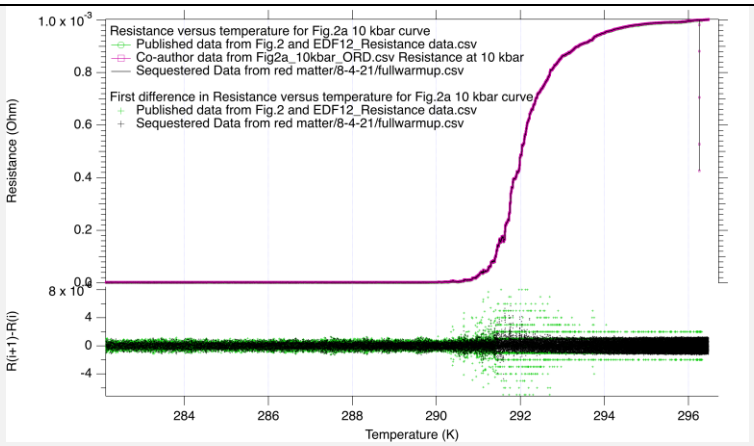


**Figure LuH_4: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 10 kbar in Figure 2a of the Nature 2023 (LuH) Paper (same datasets as those in Figure LuH_3, above). Top Panel:** R(T) over a narrow temperature range near 290 K. **Bottom Panel:** First difference of the resistance ((R(i+1)-R(i)), where i is the index in the temperature series) versus temperature for the published data (green) and sequestered data (black). Both panels share the same temperature axis. Strong similarities indicate that the published data (green) were derived from the sequestered data (black), but discrepancies in the first difference graph reveal that the published data have been altered. In particular, the first difference of the published data (green) appears to take a finite number of values above ~290K. In contrast, the first difference of the sequestered data (black) appears random across the full temperature range.

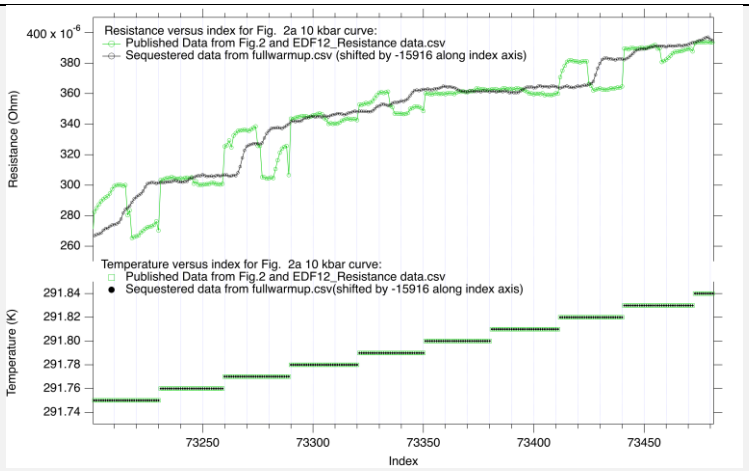


**Figure LuH, 5: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 10 kbar in Figure 2a of the Nature 2023 (LuH) Paper (same datasets as those in Figure LuH_3, above). Top Panel:** Resistance versus index over a narrow range near 292 K. **Bottom Panel**: Corresponding Temperature versus index. Both panels share the same index axis (because the published data were truncated, the sequestered data were shifted by -15916 in index). While the published and sequestered data appear indistinguishable in Figure LuH_4, above, greatly expanding the resistance scale reveals that the published data have been altered and resampled in this range. The sequestered resistance data (black) vary smoothly as expected for a continuous time series. In contrast, the published resistance data (green) exhibit sharp jumps that coincide with the incremental steps in temperature shown on the bottom panel.

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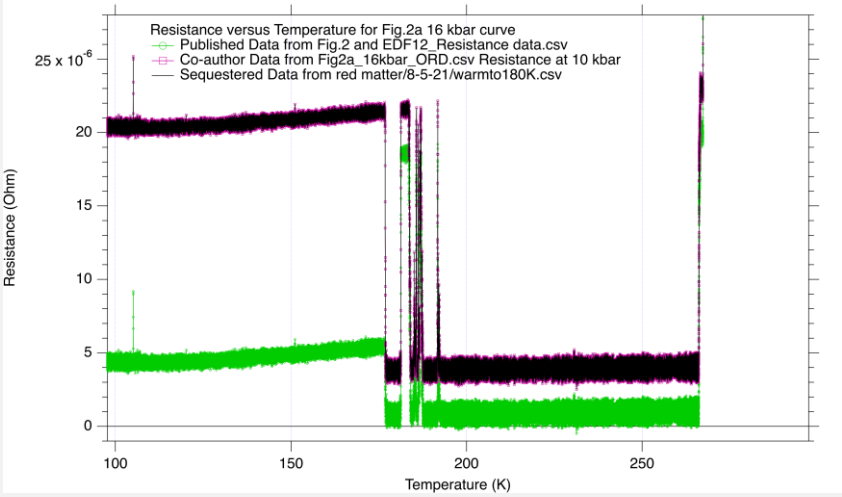


**Figure LuH_6: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 16 kbar in Figure 2a of the Nature 2023 (LuH) Paper: Green:** Data contained in the files provided by Respondent to the Investigation Committee, later referred to as "the published data"; **Magenta:** Data contained in the files provided to the Investigation Committee by the co-authors, later referred to as "the co-author data"; **Black:** Data contained in the files obtained by the Investigation Committee from the sequestered hard drives from Respondent's laboratory, later referred to as "the sequestered data." This figure shows R(T) over the full temperature range but truncates the Resistance axis at 30 micro-Ohm. The co-author data (magenta) and sequestered data (black) appear indistinguishable. In contrast, the published data (green) appear to have been altered to simulate the expected zero resistance of a superconducting sample below ~270K by subtraction of a large fraction of the signal between 100 K and ~270K.

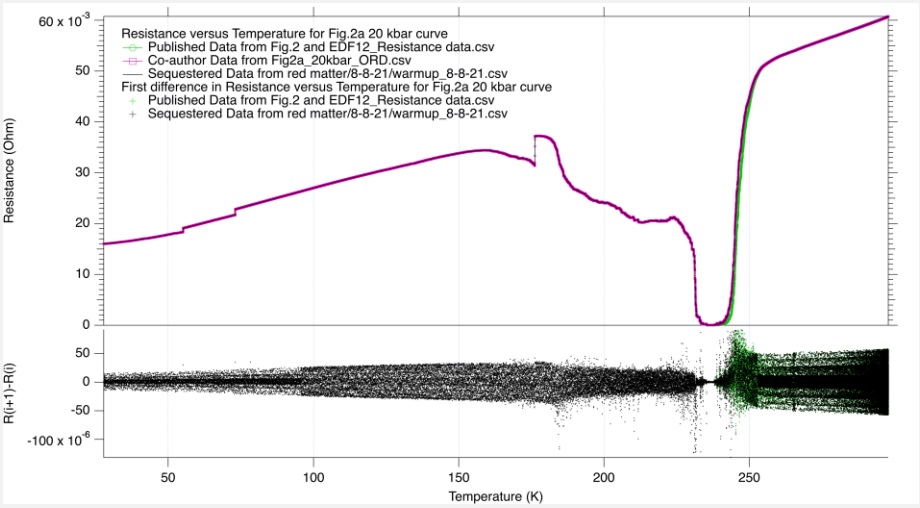


**Figure LuH_7: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 20 kbar in Figure 2a of the Nature 2023 (LuH) Paper: Green:** Data contained in the files provided by Respondent to the Investigation Committee, later referred to as "the published data"; **Magenta**: Data contained in the files provided to the Investigation Committee by the co-authors, later referred to as "the co-author data"; **Black:** Data contained in the files obtained by the Investigation Committee from the sequestered hard drives from Respondent's laboratory, later referred to as "the sequestered data." **Top Panel:** R(T) data. **Bottom Panel**: First difference of the resistance ((R(i+1)-R(i)), where i is the index in the temperature series) versus temperature for the published data (green) and sequestered data (black). Both panels share the same temperature axis. The co-author data (magenta) and sequestered data (black) appear indistinguishable. In contrast, the published data (green) appear to have been altered to simulate the expected zero resistance of a superconducting sample below ~250K by omission of data below ~235K. In addition, a small shift between the published and sequestered data in temperature and in the first difference indicates that the published data were resampled.

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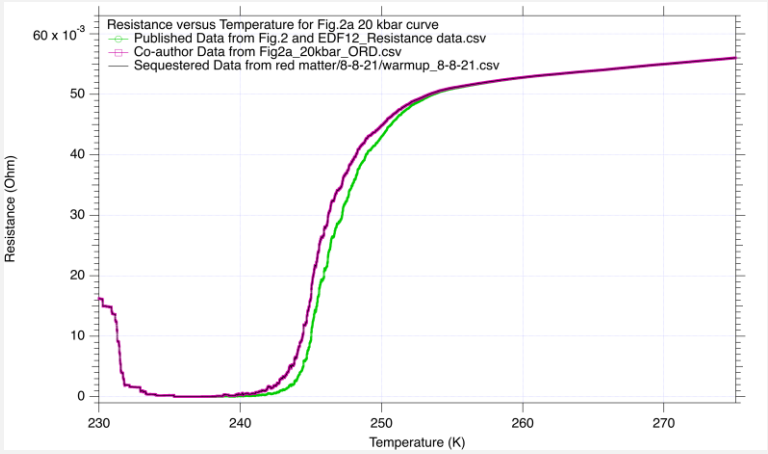


**Figure LuH_8: Analysis by the Investigation Committee: Comparison of datasets for the R(T) curve at 20 kbar in Figure 2a of the Nature 2023 (LuH) Paper (same datasets as those in Figure LuH_7).** The figure shows R(T) over a narrow range in temperature near 250 K. The co-author data (magenta) and sequestered data (black) appear indistinguishable. Strong similarities in the general trend and the noise pattern between the published (green) and sequestered (black) data indicate that the published data were derived from the sequestered data. The published data (green) appear to have been altered to simulate the expected zero resistance of a superconducting sample below ~250K by omission of data below ~235K. In addition, a small shift in temperature between the published and sequestered data indicates that the published data were resampled.

Evidence:

- Respondent failed to provide to the Investigation Committee a fulsome, raw dataset for any of the published R(T) curves displayed in **Figure 2a** from the Nature 2023 (LuH) Paper, despite repeated, specific requests from the Investigation Committee.[223] Instead, Respondent provided the Investigation Committee with an electronic file that is identical to the one published on the Zenodo repository[224] and contains the same data as the "source data file" accompanying the paper on *Nature*'s website (see Table LuH_1, above). Analysis by the Investigation Committee reveals that the R(T) datasets contained in these files (later referred to as the "published data") correspond to the three curves labeled 10, 16, and 20 kbar shown in **Figure 2a**.[225] Respondent noted during interviews with the Investigation Committee that the files provided were generated from Origin (a data analysis software tool), not the laboratory recording tool (typically LabVIEW).[226] Respondent agreed, both verbally and in writing, to provide the original files containing the raw data to the Investigation Committee but, to date, has not.

[223] *See* Exhibit H.
[224] *See* Figure 2 and Extended Data Figure 12 Resistance Data (on file as Fig.2 and EDF12_Resistance data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1 and https://www.nature.com/articles/s41586-023-05742-0#Sec20 (under the link "Source Data Fig. 2").
[225] *See* Figures LuH_1–8, above.
[226] *See* R. Dias Interview (Jul. 7, 2023) 55:3-56:20.

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- In a letter to a senior editor at *Nature* dated September 8, 2023, and in a supporting document,[227] current and former members of Respondent's laboratory[228] made numerous, specific allegations insinuating that Respondent carried out substantial data manipulation of the R(T) data shown in **Figure 2a** of the Nature 2023 (LuH) Paper. These allegations include background removal, selective omission of low-temperature data, and replacement of data by resampled values.

- Former members of Respondent's laboratory who were directly involved in the collection of the data at issue assisted the Investigation Committee in locating relevant sequestered materials and by providing an electronic notebook[229, 230] and measurement data files (later referred to as the "co-author data").[231]

- The Investigation Committee obtained multiple data files from the sequestered hard drives from Respondent's laboratory (later referred to as the "sequestered data"),[232] which appear to contain the original (unaltered) data used to prepare **Figure 2a** of the Nature 2023 (LuH) Paper. The existence of these files contradicts written correspondence (in response to the Investigation Committee's first request for material) in which Respondent stated: "I want to confirm that I have provided all available documentation, data, and information in accordance with the Committee's request. In cases where certain requested information is not within our possession, I have included additional information in this correspondence."[233]

- Analysis by the Investigation Committee[234] including comparison of the published data, the co-author data, and the sequestered data, reveals substantial data manipulation of the R(T) data shown in **Figure 2a** of the Nature 2023 (LuH) Paper. This contradicts repeated statements by Respondent in the post-publication review process that the published figures represent unaltered data.[235] Undisclosed alterations include removal of a significant fraction of the signal over extensive temperature ranges, selective omission of low-temperature data, and replacement of data by resampled values.[236] Specifically, analysis by the Investigation Committee determined that:

    - The R(T) datasets contained in the sequestered data files are identical to those contained in the co-author data files.

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[227] Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615*, 244-250 (Aug. 31, 2023) (on file as LuH-N-concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023); Notes from Interviewee 8 (on file as Synth30_EDF13a Sample Write Up.pdf) (Provided by Interviewee 8 to the Investigation Committee).

[228] Letter from Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5, Interviewee 4, Keith V. Lawler & Interviewee 7, to Tobias Roedel (Sep. 8, 2023) (on file as Letter to Nature 09-08–2023 Final.pdf).

[229] Interviewee 5, *Redmatter Project (2021-2022)* (on file as DD_RedmatterNotes_2021-2022.pdf) (Notes provided by Interviewee 5 to the Investigation Committee).

[230] *See* Figure LuH_2, above.

[231] *See* Table LuH_1, above.

[232] *See id*.

[233] Email from Respondent to Stephen Dewhurst (Jun. 8, 2023, 10:26:06am EDT) in Exhibit H.

[234] Investigation Committee, *Detailed examination of LuH Electrical Resistance data and published Figures* (Dec. 22, 2023) (on file as LuH_R.pdf) (Investigation Committee's analysis of LuH resistance data).

[235] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* 2 (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).

[236] *See* Table LuH_1, Figure LuH_1, and Figures LuH_3–8.

- The sequestered data files include several columns and span the full range of temperatures from cryogenic (10-50 K) to room temperature (300 K),[237] consistent with expectations for raw data files based on testimony from Interviewee 8.[238, 239]
- The curve labeled "10 kbar" in **Figure 2a** of the Nature 2023 (LuH) Paper was derived from data collected on August 4, 2021, by Interviewee 5.[240] As illustrated in Figures LuH_2–5, above, the published data were altered to simulate the expected zero resistance of a superconducting sample below ~290K: subtraction of a large fraction of the signal between 100 K and 290K, omission of data below 100 K, and replacement of data by resampled values.
- The curve labeled "16 kbar" in **Figure 2a** of the Nature 2023 (LuH) Paper was derived from data collected on August 5, 2021, by Interviewee 5.[241] As illustrated in Figure LuH_6, above, the published data were altered to simulate the expected zero resistance of a superconducting sample below ~270K: subtraction of a large fraction of the signal between 100 K and ~270K.
- The curve labeled "20 kbar" in **Figure 2a** of the Nature 2023 (LuH) Paper was derived from data collected on August 8, 2021, by Interviewee 5.[242] As illustrated in Figures LuH_7 and LuH_8, above, the published data were altered to simulate the expected zero resistance of a superconducting sample below ~250K: omission of data below ~235K. In addition, a small shift in temperature between the published data and the sequestered data indicates that the published data were resampled.

- Inspection of a sequestered physical notebook[243] and of the content of the sequestered electronic data folders containing the sequestered data outlined in Table LuH_1 also reveals that resistance data routinely were collected during both cooling and warming, and generally archived in a separate file. Typical filenames for data collected during warming include "warm" or "w," while typical filenames for data collected during cooling include "cool" or "c."[244]
  - Comparison of (i) the sequestered data at 10, 16 and 20 kbar collected upon warming and (ii) the corresponding additional sequestered data collected upon cooling reveals that the observed large changes in resistance typically occurred at very different temperatures upon warming and cooling.[245] In at least one case, large changes in resistance occurred at

[237] *See* Figure LuH_1, above.
[238] *See* Interviewee 8 Interview (Jul. 20, 2023) 27:21-29:19.
[239] *See* Figure LuH_1, above.
[240] 10Kbar data collected by Interviewee 5 on August 4, 2021 (on file as Fig2a 10kbar ORD.csv) (Originally saved as red matter/8-4-21/fullwarmup.csv, and made available to the Investigation Committee through sequestered hard drives).
[241] 16Kbar data collected by Interviewee 5 on August 5, 2021 (on file as Fig2a 16kbar ORD.csv) (Originally saved as red matter/8-5-21/warmto180K.csv, and made available to the Investigation Committee through sequestered hard drives).
[242] 20Kbar data collected by Interviewee 5 on August 8, 2021 (on file as Fig2a 20kbar ORD.csv) (saved as red matter/8-8-21/warmup 8-8-21.csv, and made available to the Investigation Committee through sequestered hard drives).
[243] *See* Figure LuH_2, above.
[244] *See, e.g.*, the additional sequestered data in Table LuH_1.
[245] *See* Table LuH_1 and Figure LuH_5, above.

temperatures differing by up to 250 K.[246, 247]

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Figure 2a** of the Nature 2023 (LuH) Paper, despite all measurements from which the figure was derived having been conducted at the University in Respondent's laboratory, based on evidence found by the Investigation Committee within sequestered materials. Instead, the evidence reviewed demonstrates that Respondent provided falsified and/or fabricated data to the public as "source data," accompanying the Nature 2023 (LuH) Paper and on Zenodo repository. Comparison of the published figure and data obtained from Respondent (also available from Zenodo and the *Nature* website) with data obtained from Respondent's co-authors and data obtained from the sequestered hard drives from Respondent's laboratory reveals profuse data manipulation, including: (1) subtraction of a large fraction of the resistance signal over large temperature ranges; (2) selective omission of low-temperature data; and (3) resampling of data.[248]

These acts were performed with the apparent aim of concealing the occurrence of erratic drops and jumps in the resistance data as a function of temperature, the presence of which would undermine the claim of superconducting behavior in LuH. This is a strong departure from common practice in the condensed matter physics and high-pressure physics communities.

The Investigation Committee further determined that Respondent repeatedly lied during the post-publication review process regarding the absence of background removal and other alterations to the published R(T) data. Respondent was dishonest with the Investigation Committee in claiming (in written correspondence) that the raw data files were not in his possession—an assertion contradicted by the discovery of relevant data files in the sequestration process,[249] from which the published curves in **Figure 2a** were derived.

Respondent was also dishonest with the Investigation Committee in claiming (both verbally and in written correspondence) that only warming curves typically were measured in his laboratory[250]—an assertion contradicted by the testimonies of Respondent's former lab

[246] Anonymous authors, *Issues related to Nature volume 615, 244 (2023)* (May 2, 2023) (on file as Lu_H_N_Concern_original_version.pdf) (Expressing concerns that were raised with Nature Editors); Anonymous authors, *Response to author's rebuttal concerning issues in Nature 615, 244 (2023)* (Jun. 26, 2023) (on file as Lu_H_N_Concern_revised_version.pdf); Email from Tobias Roedel to Respondent and Other Co-Authors (Aug. 31, 2023, 2:50am) (on file as Post-publication peer review process on Nature 615, 244–250 (2023).pdf); Review report of post-publication reviewer 3 (on file as LuHN_post_publication_reviewer_3.pdf); Review report of post-publication reviewer 4 (on file as LuHN_post_publication_reviewer_4.pdf).
[247] Interviewee 5, *Redmatter Project (2021-2022)* (on file as DD_RedmatterNotes_2021-2022.pdf) (Notes provided by Interviewee 5 to the Investigation Committee).
[248] *See* Table LuH_1.
[249] Sequestered Warmup data files (on file as fullwarmup.csv, warmto180K.csv, warmup 8-8-21.csv). *See also* data provided by co-authors, above.
[250] Email from Respondent to Stephen Dewhurst (Jun. 8, 2023, 10:26:06am EDT), in Exhibit H ("Regarding the requested 'cooling data,' I want to inform you that we do not possess cooling data for the specific measurements in question. Generally, we do not collect data during the cooling process due to its fast nature and increase in pressure during cooling, which often fails to accurately represent the properties of the materials under study. Consequently, we do not have any cooling data to provide to the Investigation Committee.").

members[251] and by the existence of numerous datasets in the sequestered files that reflect recording during cooling and warming.

Multiple testimonies and documents indicate Respondent prepared the figures using the data collected by his former laboratory members and that Respondent decided which figures to include in the manuscript and what details to provide to (or conceal from) the reader, despite objections from others involved in the measurements.[252]

Conclusion:

Taken together, the evidence strongly indicates that Respondent intentionally committed data falsification and/or fabrication of the R(T) data displayed in **Figure 2a** of the Nature 2023 (LuH) Paper—a significant departure from accepted practices in the research community. Respondent also was dishonest with the editors of *Nature* during the post-publication review and the Investigation Committee during this investigation.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation D.1** constitutes research misconduct.

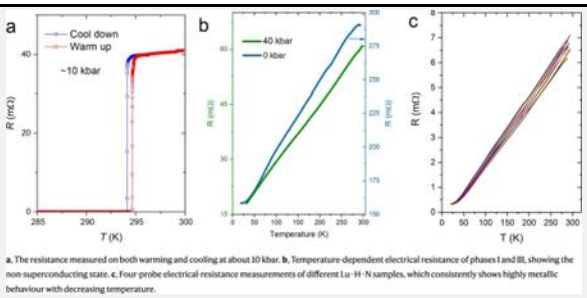
### 2. Falsification and/or fabrication of Extended Data Figure 13a, R(T) data (resistance as a function of temperature)

Context:

**Extended Data Figure 13a** aims to demonstrate that the sudden change in resistance between the superconducting state and the normal state is observed around the same temperature, both upon warming and cooling. Because the temperature sensor is not located exactly at the sample location and thermal gradients are expected to exist during cooling and warming in the high-pressure cell placed inside a cryostat, a small hysteresis of a few K is expected.

At face value, **Extended Data Figure 13a** exhibits further evidence for room-temperature superconducting behavior in LuH, indicating only 0.5 K difference between the sudden drop in resistance upon cooling and the sudden rise in resistance upon warming.

Figures for Reference:




a, The resistance measured on both warming and cooling at about 10 kbar. b, Temperature-dependent electrical resistance of phases I and III, showing the non-superconducting state. c, Four-probe electrical-resistance measurements of different Lu–H–N samples, which consistently shows highly metallic behaviour with decreasing temperature.

Extended Data Figure 13a from the Nature 2023 (LuH) Paper.

[251] *See, e.g.*, Interviewee 8 Interview (Jul. 20, 2023) 20:4-21:6.
[252] *See* evidence presented at the top of this Section III.D.

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| Datasets | Source | Path or archive location | Filename |
|---|---|---|---|
| **Published data** | Provided by Respondent | N/A | EDF13.csv |
| **Zenodo** | Zenodo public repository https://zenodo.org/records/7374510 | N/A | EDF13.csv |
| ***Nature* Source File** | N/A | https://static-content.springer.com/esm/art:10.1038/s41586-023-05742-0/MediaObjects/41586_2023_5742_MOESM6_ESM.xlsx | N/A |
| **Sequestered data (cooling)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_6.5T_cool1_2413.csv |
| **Sequestered data (warming)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_6.5T_warm1_2413.csv |
| **Sequestered data (cooling at 4 T)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_4T_cool2_2413.csv |
| **Sequestered data (warming at 4 T)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_4T_warm2_2413.csv |
| **Sequestered data (cooling at 3T)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_3T_cool3_2413.csv |
| **Sequestered data (warming at 3 T)** | Sequestered hard drive of computer in Respondent's Laboratory | 7-11-22 redMatter cond. (elliot)/2022 08 21 1.2 GPa 6.5T field/ | 1.2GPa_magnet_3T_warm3_2413.csv |

**Table LuH_2:** Summary of relevant data files for Extended Data Figure 13a of the Nature 2023 (LuH) Paper.

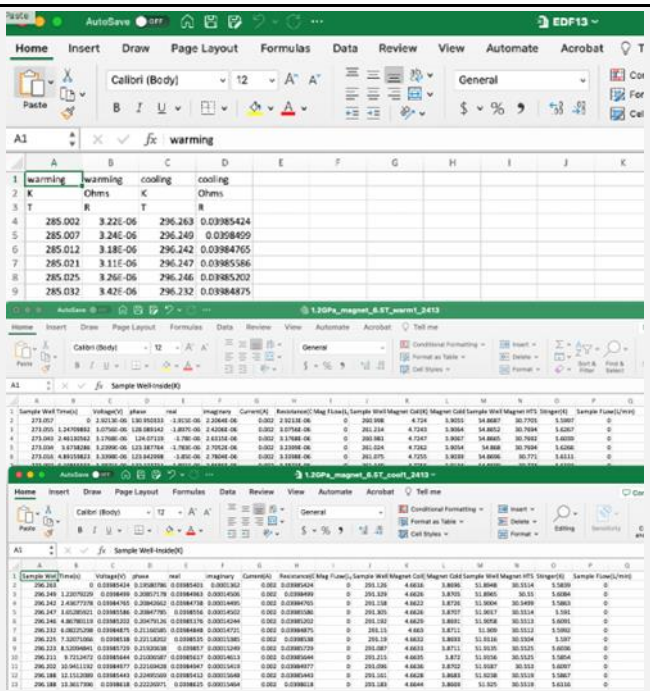


**Figure LuH_9: Comparison of datasets for the Extended Data Figure 13a of the Nature 2023 (LuH) Paper. Top:** Data file provided by Respondent to the Investigation Committee and available on Zenodo repository (but not present as source data file on *Nature* website): EDF13.csv, later referred to as the "published data."[253] **Bottom:** Data files obtained by the

[253] Data file for Extended Data Figure 13 (on file as EDF13.csv), *also available at* https://zenodo.org/records/7374510 (select the link "EDF13.csv").

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Investigation Committee from the sequestered hard drives from Respondent's laboratory: 1.2GPa_magnet_6.5T_warm1_2413.csv and 1.2GPa_magnet_6.5T_cool1_2413.csv, later referred to as the "**sequestered data**." Comparison of the sequestered and published data file structure reveals that the sequestered data contains multiple columns including "Time series." In contrast, the published data file only contains two columns (T and R) for each measurement (warming and cooling).

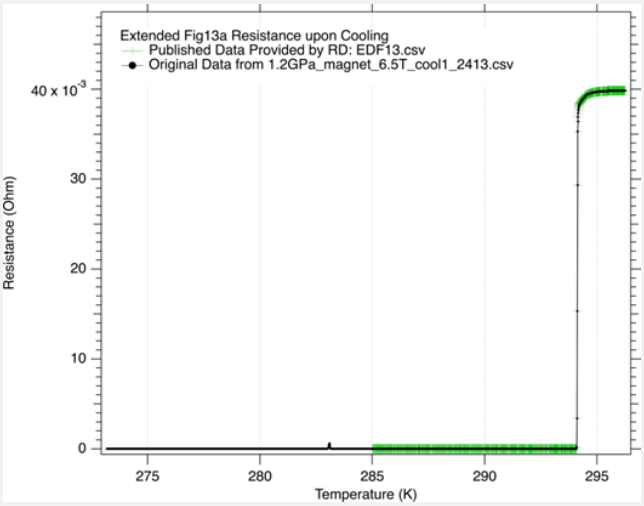


**Figure LuH_10: Comparison of datasets for the cooling curve in Extended Data Figure 13a of the Nature 2023 (LuH) Paper**. Strong similarities (see more details in LuH_17) indicate that the published data (green) were derived from the sequestered data (black). The published data (green) were altered to simulate the expected zero resistance of a superconducting sample below ~290K by omission of data below 285K.

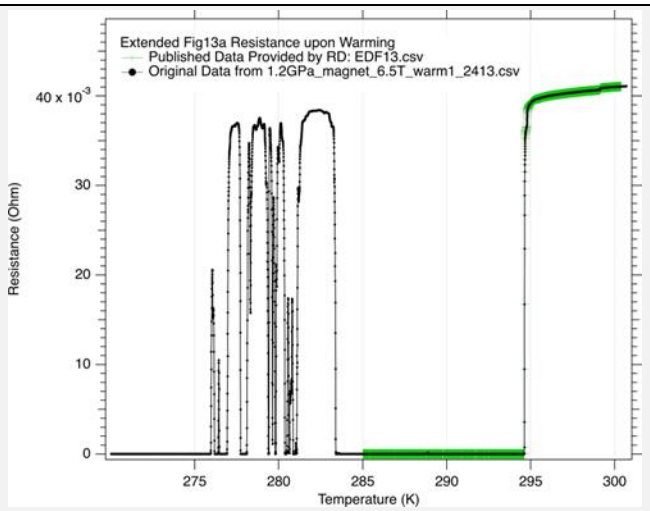


**Figure LuH_11: Comparison of datasets for the warming curve in Extended Data Figure 13a of the Nature 2023 (LuH) Paper.** Strong similarities (see more details in LuH_17) indicate that the published data (green) were derived from the sequestered data (black). The published data (green) were altered to simulate the expected zero resistance of a superconducting sample below ~290K by omission of data below 285K.

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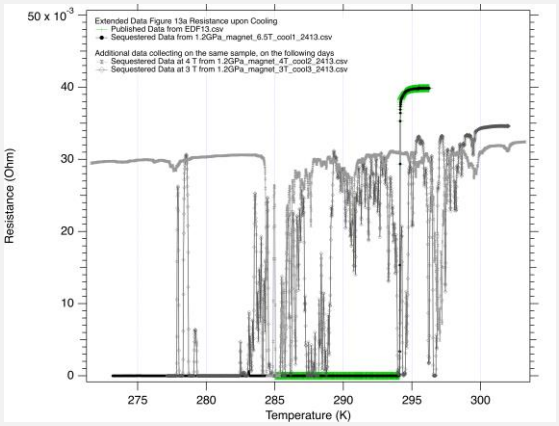


**Figure LuH_12: Comparison of datasets for the cooling curve in Extended Data Figure 13a of the Nature 2023 (LuH) Paper (data shown in Figure LuH 10) together with additional sequestered data collected upon cooling with the same sample, in the days following, subjected to 4T and 3T magnetic fields.** The additional **sequestered data** contain numerous sudden changes between finite (~50mOhm) and near zero resistance. This strongly indicates that the drop observed at 6.5 T was not a genuine superconducting transition, but rather an intermittent faulty electrical connection.

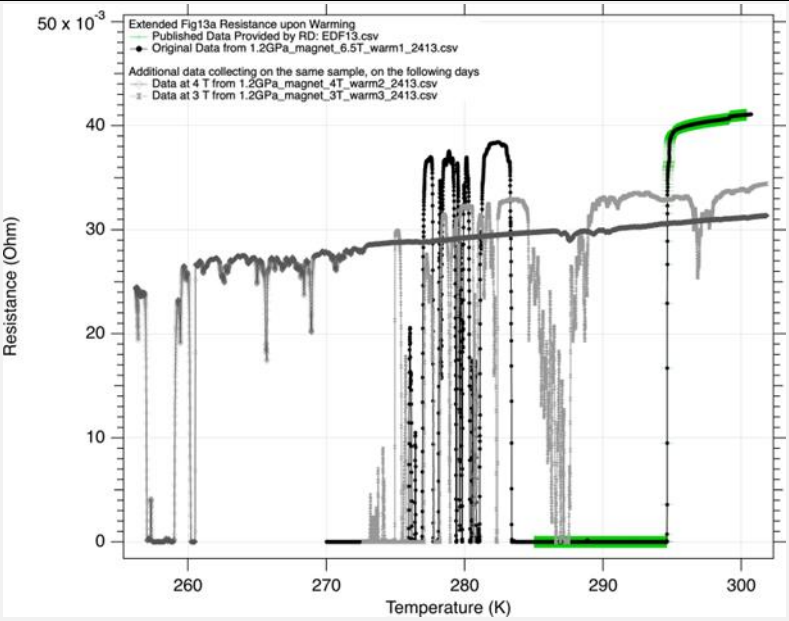


**Figure LuH_13: Comparison of datasets for the warming curve in Extended Data Figure 13a of the Nature 2023 (LuH) Paper (data shown in Figure LuH_11) together with additional sequestered data collected upon warming with the same sample, in the days following, subjected to 4T and 3T magnetic fields**. The additional **sequestered data** contain numerous sudden changes between finite (~50mOhm) and near zero resistance. This strongly indicates that the drop in resistance observed near 290 K with a 6.5 T magnetic field applied was not a genuine superconducting transition, but rather an intermittent faulty electrical connection.

Evidence:

- Respondent failed to provide to the Investigation Committee a fulsome, raw dataset for the published R(T) curves in **Extended Data Figure 13a**. A data file named EDF13.csv was provided by Respondent to the Investigation Committee and made available on the Zenodo

repository, but this file is not present on the *Nature* website as source data.[254] As shown in Figure LuH_9 (above), EDF13.csv only contains two columns (T, R) for the cooling curve and two columns (T, R) for the warming curve. Respondent stated during interviews with the Investigation Committee that the files he provided to the Investigation Committee were not the original files (*i.e.*, not the raw data), but had been generated from Origin (a data analysis software tool) and not the laboratory recording tool (typically a LabVIEW program).[255] In his testimony to the Investigation Committee,[256] Respondent agreed to provide to the Investigation Committee the original files containing the raw data but failed to do so.

- Analysis by the Investigation Committee reveals that the R(T) datasets contained in EDF13.csv correspond to the two curves displayed in **Extended Data Figure 13a**, labeled "Cool Down" and "Warm up."
- The Investigation Committee obtained the original, raw data files used to produce **Extended Data Figure 13a** from the sequestered hard drives from Respondent's laboratory.
    - These data were collected by Interviewee 8 on August 21, 2021.[257]
    - A detailed analysis by the Investigation Committee reveals strong similarities and matching noise patterns between the R(T) datasets contained in the published data file EDF13.csv provided by Respondent and the data contained in the sequestered files, indicating that the curves provided by Respondent were indeed derived from the data in the sequestered files.[258]
- Figures LuH_10 and LuH_11 (above) demonstrate that the published curves omitted low-temperature data below 285 K to conceal observations of erratic jumps and drops in resistance at temperatures below the purported critical temperature and to simulate the expected zero resistance of a superconducting sample. In contrast, R(T) over the full—yet quite narrow—temperature range (270 K to 300 K) reveals erratic behavior in R(T) upon warming, with multiple sudden drops and jumps.
- Additional R(T) data were collected by Interviewee 8, in the days following, on the same sample subjected to lower magnetic fields (3T and 4T).[259] Figures LuH_12 and LuH_13, above, compare the R(T) data collected at 6.5T with the R(T) data collected at 3T and 4T upon cooling and warming, respectively. The data at 3T and 4T demonstrate even more erratic jumps and drops in resistance.

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[254] *Id*.
[255] *See* R. Dias Interview (Jul. 7, 2023) 55:3-56:20.
[256] *See* R. Dias Interview (Jul. 14, 2023) 58:12-19.
[257] Sequestered data files at 6.5T for Extended Data Figure 13 (on file as 1 1.2 GPa_magnet_6.5T_warm1_2413.csv, and 1.2 GPa_magnet_6.5T_cool1_2413.csv.) (Collected by Interviewee 8 on August 21, 2021 and originally saved in folder titled 7-11-22 redMatter cond. (elliot), subfolder 2022 08 21 1.2 GPa 6.5T field).
[258] Investigation Committee, *Detailed examination of LuH Electrical Resistance data and published Figures* (Dec. 22, 2023) (on file as LuH_R.pdf) (Investigation Committee's analysis of LuH resistance data).
[259] Sequestered data files at 4T for Extended Data Figure 13 (on file as 1.2 GPa_magnet_4T_warm2_2413.csv, and 1.2 GPa_magnet_4T_cool2_2413.csv.) (Collected by Interviewee 8 on August 21, 2021). Sequestered data files at 3T for Extended Data Figure 13 (on file as 1.2 GPa_magnet_3T_warm3_2413.csv, and 1.2 GPa_magnet_3T_cool3_2413.csv.) (Collected by Interviewee 8 on August 21, 2021).

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- Slack correspondence between Interviewee 8 and Respondent reveals that Respondent ignored Interviewee 8's observation that one of the contacts was lost during the measurement of the data used to produce **Extended Data Figure 13a** and that the resistance determined from the combination of a preamplifier with a lock-in amplifier set-up was similar, regardless of whether one of the electrical contacts was disconnected.[260]
- The raw data file names (which include "6.5T"), a letter (with accompanying background materials) provided to *Nature* editors by former members of Respondent's laboratory, [261, 262] and materials provided to the Investigation Committee by Interviewee 8,[263] all confirm that Respondent ignored Interviewee 8's concern that the caption for **Extended Data Figure 13a** did not accurately convey that the measurement had been collected under a magnetic field of 6.5 T.[264]

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[260] *See* Slack Correspondence between Interviewee 8 and Respondent (Aug. 29, 2023) (on file as Snips of Email and Slack Messages_Received 2023-08-29.pdf) (Provided by Interviewee 8 to the Investigation Committee).

[261] Letter from Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5, Interviewee 4, Keith V. Lawler & Interviewee 7, to Tobias Roedel, Senior Editor, Nature (Sep. 8, 2023) (on file as Letter to Nature 09-08-2023 Final.pdf). ("**Resistance Measurement, Extended Data Figure 13a**—The resistance measurements shown in Extended Data Figure 13a do not have all necessary information disclosed. Specifically, the measurements were performed under a 6.5 tesla field. When this issue was brought to Dr. Dias's attention for inclusion in the manuscript, Dr. Dias said that the field does not matter, and that we do not have to disclose this information. Additional anomalies can be identified when the raw data are plotted over the entire temperature range.") (emphasis in original).

[262] Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615*, 244-250 (Aug. 31, 2023) (on file as LuH-N-concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023) ("The resistance measurements shown in EDF 13a do not have all necessary information disclosed. The measurements were performed under a 6.5 Tesla field and when these concerns were brought to Prof. Dias, he said "the field does not matter and we do not have to disclose it." Additional concerns are brought up in the raw data when plotted over the entire temperature range").

[263] Notes from Interviewee 8 (on file as Synth30_EDF13a Sample Write Up.pdf) (Provided by Interviewee 8 to the Investigation Committee) ("When I brought this issue up to Ranga he told me that he only wanted to use this as an example and that "it does not matter it was under field" and that we do not need to disclose it . . .").

[264] *See* Slack Correspondence between Interviewee 8 and Respondent (Aug. 29, 2023) (on file as Snips of Email and Slack Messages_Received 2023-08-29.pdf) (Provided by Interviewee 8 to the Investigation Committee):

> Spoke with Ranga on November 29th, 2022, at ~2:30 pm. Told him that extended Figure 13A in the new redMattter paper was under 6.5T field. He said he knew, but that it wasn't important and that he only wanted to show a cooling and warming (one with a sharp drop with cooling/warming close together). I reiterated that I think it's important to mention the applied field in the paper. He responded that the field doesn't really matter, it just shifts the Tc. Later he said both that the field didn't really do anything, and that he doesn't really think there was a field there. Which is super confusing because it can't be both, and it was definitely applied, but I just want to record what was discussed. He later asked what I thought about the paper. I said that I think the main section is written fine. I then said, "the methods section on synthesis is well, how you wrote it" (implying at least in my head that it isn't right) and left it at that. He said he took part of what Ray did as basis for the synthesis (which is true that part of what he wrote is similar to Ray's synthesis, however, it is embellished and steps/information were added that are not true). He later commented that he had to write something in the synthesis section but doesn't want to say everything because he doesn't want others to "scoop" us. I later asked a generic question about why Nature journal if they seem willing to just retract papers, and his response was it was mostly a political response as others suggested. If Nature accepts this paper even after the earlier retraction, it shows their decision to retract was not scientific based. Finished this conversation with a quick discussion on my thesis with a couple questions about the new CSH Paper.

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Extended Data Figure 13a** of the Nature 2023 (LuH) Paper, despite all measurements from which the figure was derived having been conducted at the University in Respondent's laboratory. Instead, the evidence reviewed demonstrates that Respondent provided falsified data to the public as "source data" on Zenodo repository. Comparison of the published figure and data obtained from Respondent (also available from Zenodo) with data obtained from the sequestered hard drives from Respondent's laboratory reveals profuse data omission with the apparent aim of concealing the occurrence of erratic drops and jumps in the resistance data as a function of temperature,[265] the presence of which would undermine the claim of superconducting behavior in LuH. Furthermore, additional R(T) data obtained on the same sample subjected to lower magnetic field (3T and 4T) taken in the days following the measurements at 6.5T exhibit even more erratic drops and jumps in the resistance data at temperatures well below the purported critical temperature, clearly refuting the claim of superconducting behavior in LuH intended by the falsified data displayed in **Extended Data Figure 13a** of the Nature 2023 (LuH) Paper. Respondent also blatantly ignored concerns raised by Interviewee 8 that the erratic behavior in R(T) may be due to intermittent faulty electrical connection of some of the electrical contacts with the samples, even though there was clear evidence to support Interviewee 8's concerns. Finally, Respondent concealed (by omission) that the data displayed in **Extended Data Figure 13a** of the Nature 2023 (LuH) Paper had been collected under a high magnetic field of 6.5T. Multiple testimonies and documents indicate Respondent prepared the figures using the data collected by his former lab members and that Respondent decided which figures to include in the manuscript and what details to provide to (or conceal from) the reader, despite objections from others involved in the measurements.[266]

Conclusion:

Taken together, the evidence demonstrates that Respondent intentionally committed data falsification of the R(T) data displayed in **Extended Data Figure 13a** of the Nature 2023 (LuH) Paper—a significant departure from accepted practices in the high-pressure research community. The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation D.2** constitutes research misconduct.

### 3. Fabrication and/or falsification of Extended Data Figure 15, R(T) data (resistance as a function temperature)

Context:

Because high magnetic fields tend to destabilize superconducting behavior, the critical temperature ($T_c$) is expected to decrease under increasing applied magnetic field. **Extended Data Figure 15** includes three R(T) curves collected at 15 kbar with a magnetic field of 0T, 1T and 3T.[267] The drop to zero resistance upon decreasing temperature appears to shift to lower temperature in the R(T) curve collected with a 3T field, as expected for a superconducting

[265] *See* Table LuH_2.
[266] *See* evidence presented at the top of this Section III.D.
[267] *See* Figure LuH_15, below.

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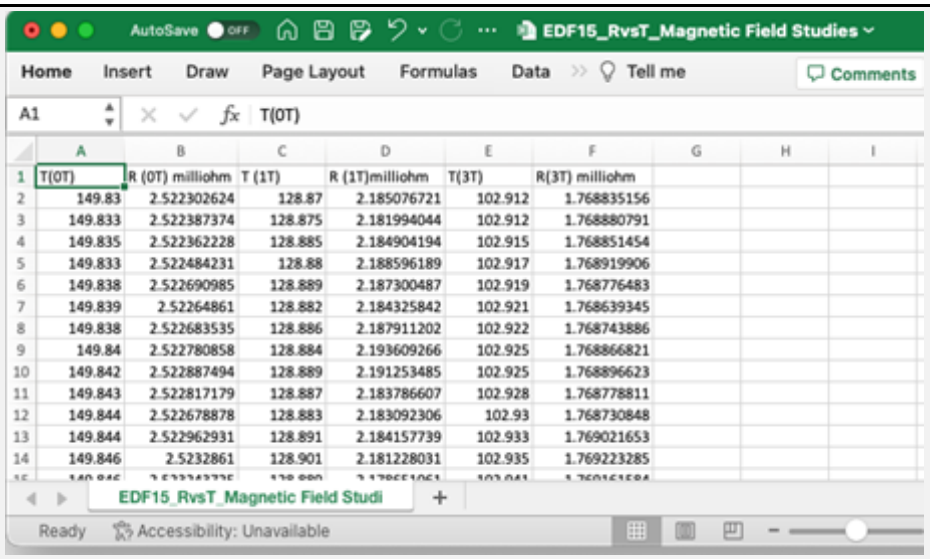
transition. The two insets describe further modeling of the shift to infer properties of the superconducting state.

Figures and Data Tables for Reference:




| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | T(0T) | R (0T) milliohm | T (1T) | R (1T)milliohm | T(3T) | R(3T) milliohm |
| 2 | 149.83 | 2.522302624 | 128.87 | 2.185076721 | 102.912 | 1.768835156 |
| 3 | 149.833 | 2.522387374 | 128.875 | 2.181994044 | 102.912 | 1.768880791 |
| 4 | 149.835 | 2.522362228 | 128.885 | 2.184904194 | 102.915 | 1.768851454 |
| 5 | 149.833 | 2.522484231 | 128.88 | 2.188596189 | 102.917 | 1.768919906 |
| 6 | 149.838 | 2.522690985 | 128.889 | 2.187300487 | 102.919 | 1.768776483 |
| 7 | 149.839 | 2.52264861 | 128.882 | 2.184325842 | 102.921 | 1.768639345 |
| 8 | 149.838 | 2.522683535 | 128.886 | 2.187911202 | 102.922 | 1.768743886 |
| 9 | 149.84 | 2.522780858 | 128.884 | 2.193609266 | 102.925 | 1.768866821 |
| 10 | 149.842 | 2.522887494 | 128.889 | 2.191253485 | 102.925 | 1.768896623 |
| 11 | 149.843 | 2.522817179 | 128.887 | 2.183786607 | 102.928 | 1.768778811 |
| 12 | 149.844 | 2.522678878 | 128.883 | 2.183092306 | 102.93 | 1.768730848 |
| 13 | 149.844 | 2.522962931 | 128.891 | 2.184157739 | 102.933 | 1.769021653 |
| 14 | 149.846 | 2.5232861 | 128.901 | 2.181228031 | 102.935 | 1.769223285 |

**Figure LuH_14:** Screen shot of the data file provided by Respondent to the Investigation Committee containing the data used to prepare Extended Data Figure 15.[268] This file was also shared by Respondent on the Zenodo repository and as a "source data" file on *Nature* website.

[268] Data File for Extended Data Figure 15 (on file as EDF15_RvsT_Magnetic Field Studies.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1 and https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-023-05742-0/MediaObjects/41586_2023_5742_MOESM17_ESM.csv.

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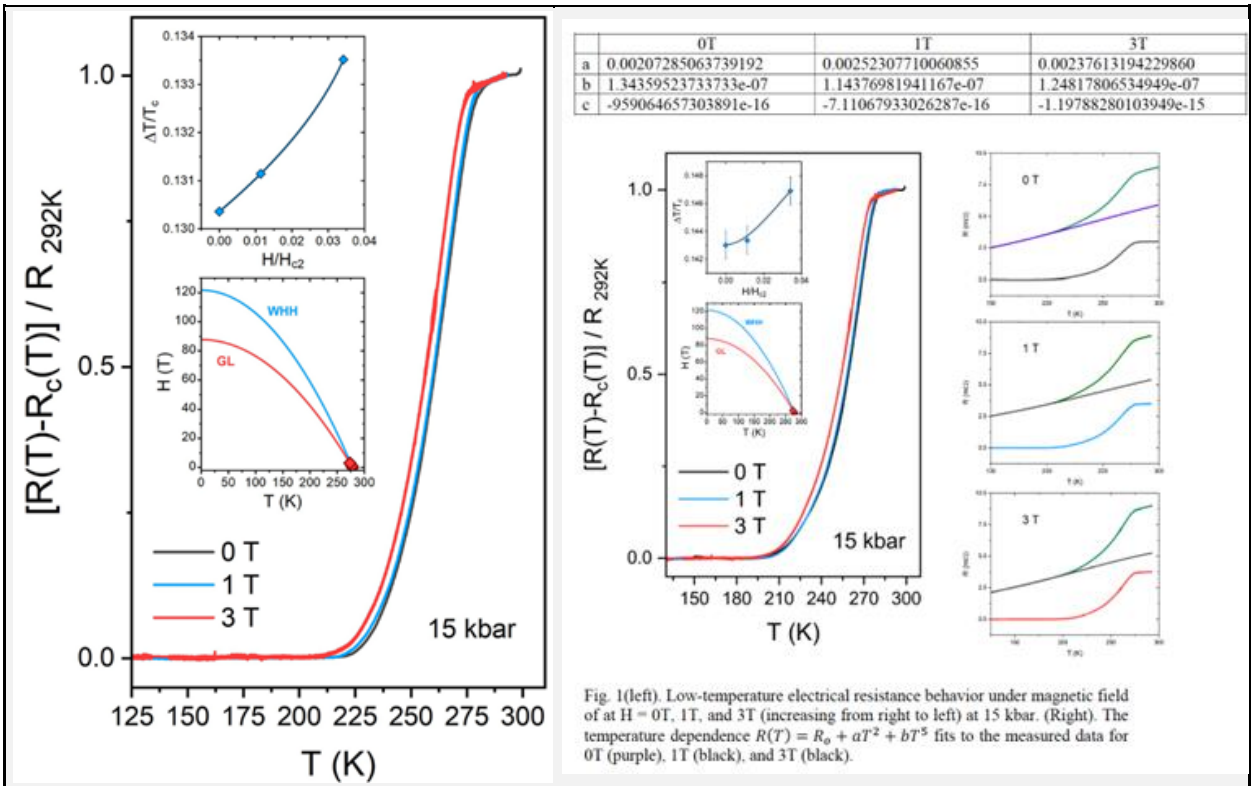


| | 0T | 1T | 3T |
|---|---|---|---|
| a | 0.00207285063739192 | 0.00252307710060855 | 0.00237613194229860 |
| b | 1.34359523733733e-07 | 1.14376981941167e-07 | 1.24817806534949e-07 |
| c | -959064657303891e-16 | -7.11067933026287e-16 | -1.19788280103949e-15 |

Fig. 1(left). Low-temperature electrical resistance behavior under magnetic field of at H = 0T, 1T, and 3T (increasing from right to left) at 15 kbar. (Right). The temperature dependence $R(T) = R_o + aT^2 + bT^5$ fits to the measured data for 0T (purple), 1T (black), and 3T (black).

**Figure LuH_15: Left:** Copy of the Extended Data Figure 15 in the Nature 2023 (LuH) Paper. Note that the original vertical label indicates that the R(T) curves are represented after subtraction of a $R_c(T)$ "background" and normalized by a factor $R_{292K}$. **Right:** Revised figure included in Respondent's reply to the concerns raised with *Nature* editors.[269]

[269] *See* Anonymous authors, *Issues related to Nature volume 615, 244 (2023)* (May 2, 2023) (on file as Lu_H_N_Concern_original_version.pdf) (Expressing concerns that were raised with Nature Editors); Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).

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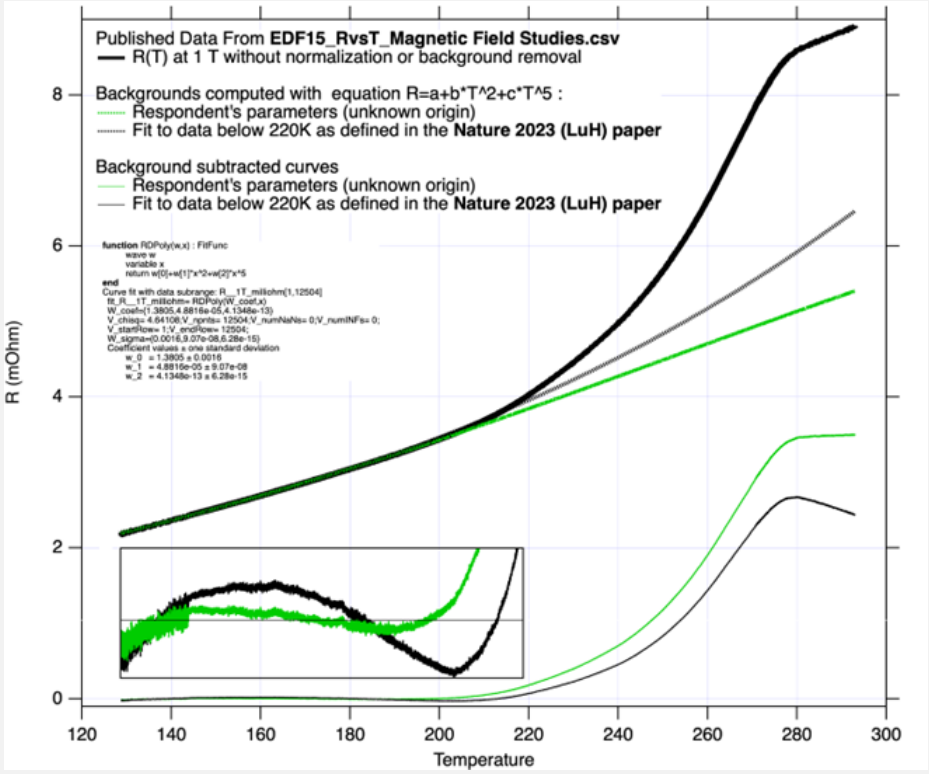


**Figure LuH_16:** Analysis by the Investigation Committee of the published data for the 1T curve in Extended Data Figure 15. Data at 1T from EDF15_RvsT_Magnetic Field Studies.csv (solid black) are shown together with two "background" curves computed using the equation $R=a+b*T^2+c*T^5$. The green "background" curve was obtained using the coefficients provided in Respondent's reply to the post-publication review.[270] The black "background" was obtained using the coefficients determined by a fit to the R(T) data below 220 K, the method described in the caption of Extended Data Figure 15. Corresponding background subtracted curves (inset) reveal that the published curve is not obtained using either method.

[270] *See* Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).

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(a)

| | 1 T |
|---|---|
| a (mΩ) | 1.3766 ±0.00157 |
| b (mΩ/K²) | 4.90697E-5 ±8.95017E-8 |
| c (mΩ/K⁵) | 3.92581E-13 ±6.21443E-15 |

(b)

| | 0 T | 1 T | 3 T |
|---|---|---|---|
| a (mΩ) | 1.404(2) | 1.381(2) | 1.170(1) |
| b (mΩ/K²) | $4.727(7)\times10^{-8}$ | $4.881(9)\times10^{-8}$ | $5.970(7)\times10^{-8}$ |
| c (mΩ/K⁵) | $9.36(4)\times10^{-13}$ | $4.14(6)\times10^{-13}$ | $1.5(5)\times10^{-14}$ |

(c)

| | 0T | 1T | 3T |
|---|---|---|---|
| a | 0.00207285063739192 | 0.00252307710060855 | 0.00237613194229860 |
| b | 1.34359523733733e-07 | 1.14376981941167e-07 | 1.24817806534949e-07 |
| c | -9590646573038916-16 | -7.11067933026287e-16 | -1.19788280103949e-15 |

Fig. R7 The comparison of my fit parameters (a) with these provided by author of an anonymous paper (b) and the authors of the Nature paper (c).

| 1T Data | Parameters from Lu_H_N_Reply_original_version.pdf | Parameters from Lu_H_N_Reply_original_version.pdf divided by 0.002 | Fit to the data below 220 K |
|---|---|---|---|
| a | 0.002523077 | 1.2615385 | 1.3805 |
| b | 1.14E-07 | 5.72E-05 | 4.88E-05 |
| c | -7.11E-16 | -3.56E-13 | 4.13E-13 |

**Figure LuH_17: Comparison of background coefficients for the curves displayed in Extended Data Figure 15. Top:** Figure R7 from the Post-Publication Reviewer 3 report[271] comparing the "background" coefficients. Panels (a) and (b) show the coefficients determined by Reviewer 3 and the anonymous authors using a fit to the data below 220 K, the method described in the caption of Extended Data Figure 15. The coefficients a and b are very similar (relative difference <0.5%), while coefficient c matches to 5% (note there is an apparent typo in the exponent of coefficient b). This demonstrates that fitting the data below 220 K yields very similar coefficients, regardless of the software or exact methodology used. In contrast, the parameters provided by Respondent in Lu_H_N_Reply_original_version.pdf are strikingly different.[272] **Bottom: Analysis by the Investigation Committee:** Second column shows the coefficients for the 1T "background" given in Respondent's reply[273] to the anonymous authors' concerns to *Nature*.[274] Third column shows the coefficients from the second column divided by 0.002 as Respondent indicated in the reply to the post-publication review.[275] Neither of these sets of coefficients agree with results from the fits performed by the Investigation Committee (fourth column). While coefficients a and b are within 10% and 17%, respectively, the sign of coefficient c is incorrect. Note that the coefficients obtained by Reviewer 3 and the Investigation Committee agree to better than 0.6%.[276]

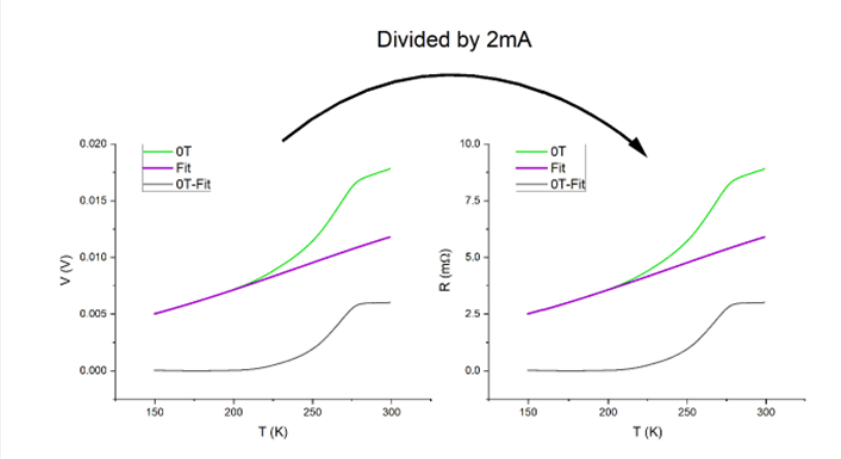


**Figure LuH_18: Excerpt from page 4 of Respondent's reply to the post-publication review on the 2023 Nature (LuH) Paper.**[277] This figure reports the data for the curve at 0T Extended Data Figure 15. **Left:** Data in Voltage units. **Right:** Resistance units. The tick labels of the vertical axis plot of the data in voltage are obviously incorrect: dividing 0.020 Volts, the span of the voltage scale, by 0.002 Amperes yields R=10 Ohm, not 10 mOhm as shown on the plot on the right).

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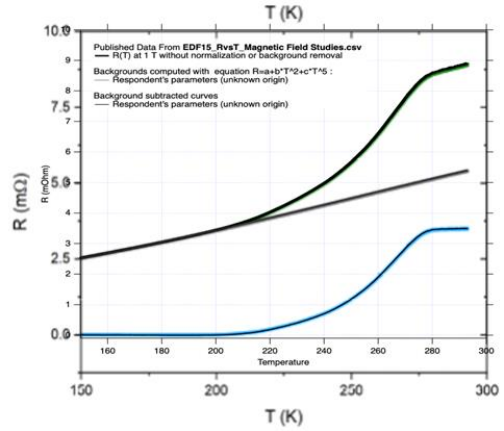


**Figure LuH_19: Analysis by the Investigation Committee relative to the 1T curve in Extended Data Figure 15.** Overlaid graphs: (1) R(T) data at 1 T from **EDF15_RvsT_Magnetic Field Studies.csv** with "background" obtained using the coefficients in the third column of the bottom panel in Figure LuH_17 and the corresponding background subtracted curve (black curves), and (2) the corresponding graph from Respondent's reply to the post-publication review (colored curves, *see* Figure LuH_15 right side, center graph).[278] The overlaid graphs demonstrate that using the coefficients in the third column of the bottom panel in Figure LuH_17 (*i.e.*, the parameters from Respondent's LuH_3, divided by 0.002 following the prescription in LuH_13) to compute the "background" yields a "background" identical to Respondent's plot in the right panel in Figure LuH_15. However, this does not resolve the striking discrepancy between the background curve shown here and the background obtained following the method indicated in the Nature 2023 (LuH) Paper (*i.e.*, a fit to the data below 220K).

Evidence:

- Respondent failed to provide to the Investigation Committee a fulsome, raw dataset for the published R(T) curves in **Extended Data Figure 15** from the Nature 2023 (LuH) Paper, despite repeated, specific requests from the Investigation Committee.[279] Instead, Respondent provided the Investigation Committee a data file named EDF15_RvsT_Magnetic Field

[271] Review report of post-publication reviewer 3 (on file as LuHN_post_publication_reviewer_3.pdf).
[272] *See* Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[273] *Id*.
[274] Anonymous authors, *Issues related to Nature volume 615, 244 (2023)* (May 2, 2023) (on file as Lu_H_N_Concern_original_version.pdf) (Expressing concerns that were raised with *Nature* Editors).
[275] Letter from Respondent to Tobias Roedel (Sep. 3, 2023) (on file as Response to Nature post publication referee comments.pdf) (Respondent's reply to the post-publication review).
[276] *See* Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf); and Letter from Respondent to Tobias Roedel (Sep. 3, 2023) (on file as Response to Nature post publication referee comments.pdf) (Respondent's reply to the post-publication review).
[277] Letter from Respondent to Tobias Roedel (Sep. 3, 2023) (on file as Response to Nature post publication referee comments.pdf) (Respondent's reply to the post-publication review).
[278] *Id*.
[279] *See* Exhibit H.

Studies.csv that also is available on the Zenodo repository and as source data file on the *Nature* website.[280] As shown at Figure LuH_14, above, the file EDF15_RvsT_Magnetic Field Studies.csv only contains two columns (T, R) for each R(T) dataset at 0T, 1T, and 3T.[281]

- In May 2023, "Anonymous authors" communicated concerns regarding the Nature 2023 (LuH) Paper to *Nature* editors. One of these concerns regarded the background subtraction used to produce the results displayed in **Extended Data Figure 15**. At the request of *Nature* editors, Respondent prepared a reply in which Respondent claimed that an earlier version of the figure was inadvertently included which displayed background subtracted data that used a method different from that described in the Nature 2023 (LuH) Paper.[282] "Anonymous authors" then expressed further concerns,[283] prompting the *Nature* editors to initiate a post-publication review involving four additional peer-reviewers.[284] Respondent prepared and submitted a reply.[285]

- As published, **Extended Data Figure 15** provides evidence for superconducting behavior: (1) a sudden drop to zero resistance upon decrease in temperature; and (2) shift of the resistance drop to lower temperature upon increasing magnetic field. However, the data provided in the file EDF15_RvsT_Magnetic Field Studies.csv reveal: (1) no sudden drop to zero resistance upon decrease in temperature was observed; and (2) no consistent shift was induced by the applied magnetic field. This was noted by the post-publication Reviewer 4 as follows:

> The authors suggest that "To ensure accurate data analysis, we employed a standard approach to subtract the expected residual resistance resulting from sample inhomogeneity." I disagree with this statement as this is not a standard approach in transport measurements. The presence of residual resistivity due to the sample inhomogeneities at zero temperature is normally expected to occur in any metallic sample at low temperatures and it is a fundamental property of a normal metal. This procedure cannot be used as a way to convert a normal metal to a superconductor artificially by using data manipulation.[286]

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[280] Data Files for Extended Data Figure 15 (on file as EDF15_RvsT_Magnetic Field Studies.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1 and https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-023-05742-0/MediaObjects/41586_2023_5742_MOESM17_ESM.csv.
[281] *Id*.
[282] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[283] Anonymous authors, *Response to author's rebuttal concerning issues in Nature 615, 244 (2023)* (Jun. 26, 2023) (on file as Lu_H_N_Concern_revised_version.pdf).
[284] Email from Tobias Roedel to Respondent and Other Co-Authors (Aug. 31, 2023, 2:50am) (on file as Post-publication peer review process on Nature 615, 244–250 (2023).pdf); Review report of post-publication reviewer 3 (on file as LuHN_post_publication_reviewer_3.pdf); Review report of post-publication reviewer 4 (on file as LuHN_post_publication_reviewer_4.pdf).
[285] Letter from Respondent to Tobias Roedel (Sep. 3, 2023) (on file as Response to Nature post publication referee comments.pdf) (Respondent's reply to the post-publication review).
[286] Review report of post-publication reviewer 4, 4 (on file as LuHN_post_publication_reviewer_4.pdf).

- It is likely that the file EDF15_RvsT_Magnetic Field Studies.csv was not made available to pre-publication reviewers. This would explain why pre-publication reviewers did not express similar concerns as those expressed by post-publication Reviewer 4 as described above.
- The caption for **Extended Data Figure 15** indicates: "The temperature dependence of the resistance of a simple metal is written as: $R(T) = R_0 + aT^2 + bT^5$. We fit the data below $T < 220$ K for each field, at which the resistance goes to the minimum value, to that function and subtracted it out."
- Neither the "Anonymous authors" of the concern submitted to *Nature* nor the post-publication reviewers were able to reproduce the published curves of **Extended Data Figure 15** with the procedure provided in the paper.[287]
- Respondent acknowledged in his reply that the figure was an earlier version obtained with a different method and offered a revised figure and fit coefficients for the background function (see Figure LuH_15) as $\mathbf{R(T) = a + bT^2 + cT^5}$.[288] The fit coefficients provided by Respondent included a negative value for the c coefficient for all three curves (0T, 1T, and 3T).
- The "Anonymous authors" of the concern submitted to *Nature* noted that using a negative coefficient for the $T^5$ term (electron-phonon contribution to the resistance) is unphysical, in other words, the parameter **c** used to compute the background subtraction by Respondent should be positive.[289]
- Neither the "Anonymous authors" of the concern submitted to Nature[290] nor the post-publication reviewers[291] were able to reproduce the revised figure using the method described in the paper (background obtained by fitting the data below 220 K) or by using the coefficients provided by Respondent in his reply.[292]
- The "Anonymous authors" of the concern submitted to *Nature* and the four post-publication reviewers all obtained consistent fit coefficients,[293] all with a positive **c** coefficient. In

[287] *See* Figures LuH_15 and LuH_16.
[288] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[289] Anonymous authors, *Response to author's rebuttal concerning issues in Nature 615, 244 (2023)* (Jun. 26, 2023) (on file as Lu_H_N_Concern_revised_version.pdf).
[290] *Id*.
[291] Email from Tobias Roedel to Respondent and Other Co-Authors (Aug. 31, 2023, 2:50am) (on file as Post-publication peer review process on Nature 615, 244–250 (2023).pdf); Review report of post-publication reviewer 3 (on file as LuHN_post_publication_reviewer_3.pdf); Review report of post-publication reviewer 4 (on file as LuHN_post_publication_reviewer_4.pdf).
[292] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[293] There was a typo for one of the coefficients reported by the "Anonymous authors": $4.881*10^{-8}$ instead of $4.881*10^{-5}$ for **b**.

contrast, the fit coefficients given by Respondent differed by three orders of magnitude and the **c** coefficient was negative for all three cases (0T, 1T, and 3T).[294]

- Analysis by the Investigation Committee confirmed that fitting the data below 220 K yields fit coefficients very close to those obtained by the "Anonymous authors" of the concern submitted to *Nature* and the four post-publication reviewers, and that this background subtraction method does not produce curves similar to the curves in the published or revised **Extended Data Figure 15**.[295]
- In Respondent's September 3, 2023 reply to the post-publication review, Respondent states that the background coefficients should be divided by 0.002 to convert from voltage to resistance.[296, 297] The Investigation Committee notes that all curves and datasets previously provided by Respondent regarding these measurements (prior to Respondent's September 3, 2023 reply to the post-publication review) were in resistance units. Analysis by the Investigation Committee reveals that dividing the coefficients given in Respondent's original reply by 0.002 does reproduce the curves displayed in the revised figure in Respondent's original reply.[298, 299] However, this does not explain how these coefficients were obtained. In addition, the tick labels of the vertical axis plot of the data in voltage obviously are incorrect.[300]
- The Nature 2023 (LuH) Paper was retracted on November 7, 2023. The retraction notice includes the following statement: "In addition, and separately, concerns have been independently raised with the journal regarding the reliability of the electrical resistance data presented in the paper. An investigation by the journal and post-publication review have concluded that these concerns are credible, substantial and remain unresolved."[301]

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Extended Data Figure 15** of the Nature 2023 (LuH) Paper. Instead, Respondent provided partial data to the public as "source data" on Zenodo repository.[302] These data reveal a metallic behavior without any indication of a superconducting transition. Removal of the residual resistance at low temperature—incorrectly referred to as a "background subtraction"—to create the illusion of a superconducting transition to zero resistance amounts to data falsification and constitutes a

[294] *See* Figure LuH_17.
[295] *See* Figures LuH_16 and LuH_17.
[296] Letter from Respondent to Tobias Roedel (Sep. 3, 2023) (on file as Response to Nature post publication referee comments.pdf) (Respondent's reply to the post-publication review).
[297] *See* Figure LuH_18, above.
[298] *See* Figure LuH_19, above.
[299] Ranga P. Dias & Ashkan Salamat, *Ranga P. Dias' and Ashkan Salamat's Response To Anonymous "Issues Related To Nature Volume 615, 244 (2023)" Dated May 2, 2023* (May 28, 2023) (on file as Lu_H_N_Reply_original_version.pdf).
[300] *See* Figure LuH_19, above: dividing 0.020 Volts, the span of the voltage scale, by 0.002 Amperes yield R=10 Ohm not 10 mOhm, as shown in the plot on the right.
[301] Nathan Dasenbrock-Gammon, Elliot Snider, Raymond McBride, Hiranya Pasan, Dylan Durkee, Nugzari Khalvashi-Sutter, Sasanka Munasinghe, Sachith E. Dissanayake, Keith V. Lawler, Ashkan Salamat & Ranga P. Dias, *Retraction Note: Evidence of near-ambient superconductivity in a N-doped lutetium hydride*, NATURE 624, 460 (2023), https://doi.org/10.1038/s41586-023-05742-0.
[302] *See* Figure LuH_18, above.

strong departure from accepted practice in the condensed matter research community. The description of the "background" articulated in the caption of the published **Extended Data Figure 15** does not result in the curves displayed in either the published figure or the "revised" figure included in Respondent's reply to the "Anonymous authors" concerns. Furthermore, a positive value for the coefficient of the $T^5$ term, as reported by Respondent, is unphysical.

Conclusion:

Taken together, these observations strongly indicate that Respondent committed data falsification of the R(T) data displayed in **Extended Data Figure 15 of the Nature 2023 (LuH) Paper**. Respondent intentionally misled peer reviewers and the scientific community by using unorthodox background subtraction in an attempt to manipulate metallic behavior as evidence for superconductivity in LuH. These actions represent a significant departure from accepted practices in the scientific community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation D.3** constitutes research misconduct.

**4. Fabrication and/or falsification of Figure 4, C(T) data (specific heat capacity as a function of temperature)**

Context:

When a superconductor is heated slowly towards its critical temperature ($T_c$), which corresponds to the temperature at which—upon warming—the material recovers normal, finite electrical resistance, the material will exhibit a positive jump in the *specific heat capacity* (sometimes also referred to as the *specific heat*) indicative of the abrupt changes in its thermodynamic properties between the superconducting and normal states.

Demonstrating the occurrence of a specific heat anomaly at the same temperature below which the electrical resistance drops to zero is a powerful means to provide additional evidence for bulk superconducting behavior.

While specific heat measurements are more challenging to perform in a DAC than with a larger sample at ambient pressure, high-pressure calorimetry has been demonstrated in the GPa range to observe superconducting specific heat anomalies as early as two decades ago.[303]

**Figure 4** of the Nature 2023 (LuH) Paper, displayed below, and the data presented therein indicate specific heat *anomalies* at the same temperature that resistance drops to zero, which provides—when taken at face value—compelling evidence to support the claim that LuH exhibits superconductivity at room temperature near 10 kbar.

[303] *See, e.g.*, Georg Knebel, Marie-Aude Méasson, Bernard Salce, Dai Aoki, Daniel Braithwaite, Jean Pascal Brison & Jacques Flouquet, *High-pressure phase diagrams of CeRhIn5 and CeCoIn5 studied by ac calorimetry*, J. PHYS.: CONDENS. MATTER 16, 8905 (2004), https://iopscience.iop.org/article/10.1088/0953-8984/16/49/008; Alessandro Barla, Julien Derr, James Philip Sanchez, Bernard Salce, Gerard Lapertot, Bryan Patrick Doyle, Rudolf Rüffer, Roman Lengsdorf, Mohsen M. Abd-Elmeguid, and Jacques Flouquet, *High-Pressure Ground State of $SmB_6$: Electronic Conduction and Long Range Magnetic Order*, PHYS. REV. LETT. 94, 166401 (2005), https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.94.166401.

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Figures and Data Tables for Reference:

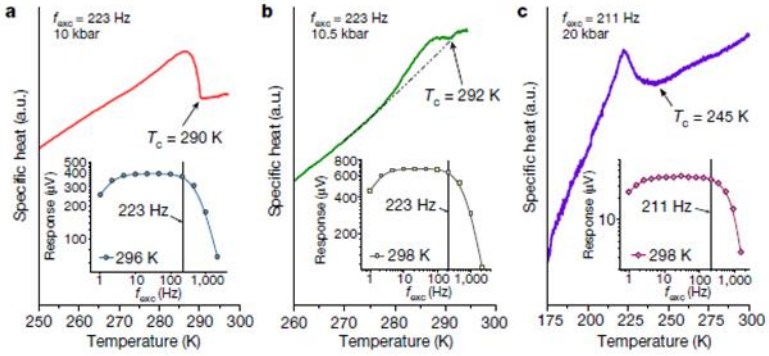


**Fig. 4 | Specific-heat-capacity measurement on the superconducting lutetium–nitrogen–hydrogen system. a–c**, Specific heat capacity of nitrogen-doped lutetium hydride at 10 kbar (**a**), 10.5 kbar (**b**) and 20 kbar (**c**), showing the superconducting transition as high as 292 K at 10.5 kbar in **b**. The drive frequency ($f_{exc}$) and frequency sweeps of each measurement are depicted in the insets. The strength of the heat-capacity anomaly associated with superconductivity varied owing to volume fraction as shown in **c**. The dashed line is a guide to the eye to distinguish the trend of the heat-capacity anomaly before and after the transition.

Figure 4 from the Nature 2023 (LuH) Paper.

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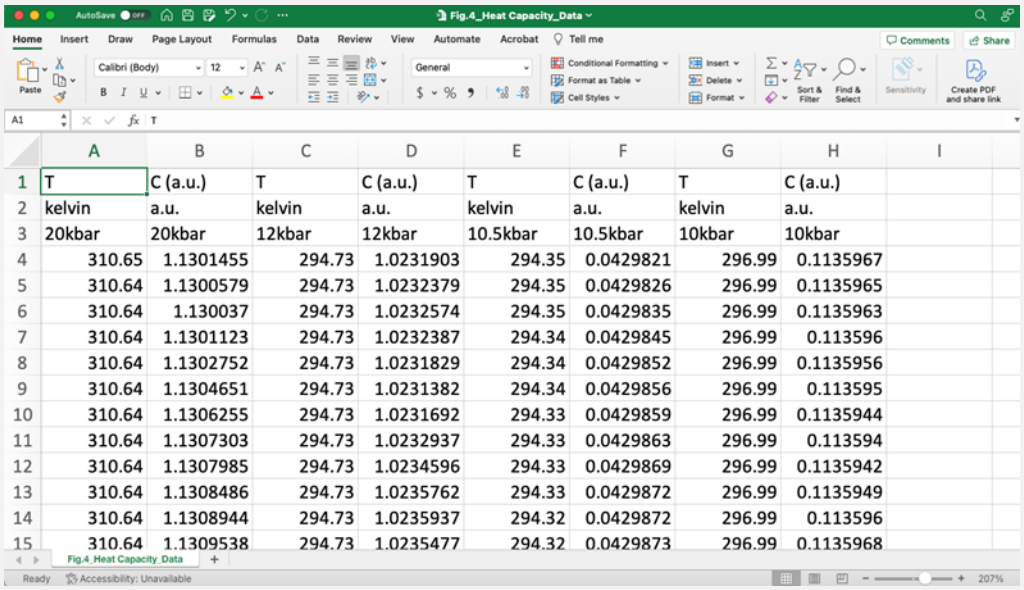

Fig.4_Heat Capacity_Data

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | T | C (a.u.) | T | C (a.u.) | T | C (a.u.) | T | C (a.u.) |
| 2 | kelvin | a.u. | kelvin | a.u. | kelvin | a.u. | kelvin | a.u. |
| 3 | 20kbar | 20kbar | 12kbar | 12kbar | 10.5kbar | 10.5kbar | 10kbar | 10kbar |
| 4 | 310.65 | 1.1301455 | 294.73 | 1.0231903 | 294.35 | 0.0429821 | 296.99 | 0.1135967 |
| 5 | 310.64 | 1.1300579 | 294.73 | 1.0232379 | 294.35 | 0.0429826 | 296.99 | 0.1135965 |
| 6 | 310.64 | 1.130037 | 294.73 | 1.0232574 | 294.35 | 0.0429835 | 296.99 | 0.1135963 |
| 7 | 310.64 | 1.1301123 | 294.73 | 1.0232387 | 294.34 | 0.0429845 | 296.99 | 0.113596 |
| 8 | 310.64 | 1.1302752 | 294.73 | 1.0231829 | 294.34 | 0.0429852 | 296.99 | 0.1135956 |
| 9 | 310.64 | 1.1304651 | 294.73 | 1.0231382 | 294.34 | 0.0429856 | 296.99 | 0.113595 |
| 10 | 310.64 | 1.1306255 | 294.73 | 1.0231692 | 294.33 | 0.0429859 | 296.99 | 0.1135944 |
| 11 | 310.64 | 1.1307303 | 294.73 | 1.0232937 | 294.33 | 0.0429863 | 296.99 | 0.113594 |
| 12 | 310.64 | 1.1307985 | 294.73 | 1.0234596 | 294.33 | 0.0429869 | 296.99 | 0.1135942 |
| 13 | 310.64 | 1.1308486 | 294.73 | 1.0235762 | 294.33 | 0.0429872 | 296.99 | 0.1135949 |
| 14 | 310.64 | 1.1308944 | 294.73 | 1.0235937 | 294.32 | 0.0429872 | 296.99 | 0.113596 |
| 15 | 310.64 | 1.1309538 | 294.73 | 1.0235477 | 294.32 | 0.0429873 | 296.99 | 0.1135968 |

coolDown

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Temperature | Finger Temp | Time(s) | Voltage(V) | phase | real | imaginary | Current(A) | heat capacity | FLow(L/min) | |
| 2 | 310.65 | 309.19 | 0 | 3.6413E-05 | -0.2326909 | 3.6413E-05 | -1.479E-07 | 0.025 | 27462.6267 | 0.72265625 | |
| 3 | 310.64 | 309.19 | 0.49441433 | 3.6389E-05 | -0.1931714 | 3.6388E-05 | -1.227E-07 | 0.025 | 27481.1183 | 0.703125 | |
| 4 | 310.64 | 309.19 | 0.99687719 | 3.6383E-05 | -0.1296182 | 3.6383E-05 | -8.231E-08 | 0.025 | 27485.5396 | 0.78125 | |
| 5 | 310.64 | 309.19 | 1.49098539 | 3.6404E-05 | -0.0502309 | 3.6404E-05 | -3.192E-08 | 0.025 | 27469.6333 | 0.6640625 | |
| 6 | 310.64 | 309.19 | 1.98108864 | 3.6449E-05 | 0.01503666 | 3.6449E-05 | 9.5658E-09 | 0.025 | 27435.2631 | 0.859375 | |
| 7 | 310.64 | 309.19 | 2.48430157 | 3.6503E-05 | 0.02403202 | 3.6503E-05 | 1.5311E-08 | 0.025 | 27395.1977 | 0.78125 | |
| 8 | 310.64 | 309.19 | 2.98594713 | 3.6548E-05 | -0.0299009 | 3.6548E-05 | -1.907E-08 | 0.025 | 27361.3648 | 0.80078125 | |
| 9 | 310.64 | 309.19 | 3.48292446 | 3.6577E-05 | -0.102043 | 3.6577E-05 | -6.514E-08 | 0.025 | 27339.2456 | 0.68359375 | |
| 10 | 310.64 | 309.19 | 3.98067665 | 3.6597E-05 | -0.1430344 | 3.6597E-05 | -9.136E-08 | 0.025 | 27324.8608 | 0.7421875 | |
| 11 | 310.64 | 309.19 | 4.47791195 | 3.6611E-05 | -0.1395971 | 3.6611E-05 | -8.92E-08 | 0.025 | 27314.2795 | 0.68359375 | |
| 12 | 310.64 | 309.19 | 4.97631359 | 3.6624E-05 | -0.1208892 | 3.6624E-05 | -7.727E-08 | 0.025 | 27304.6231 | 0.72265625 | |
| 13 | 310.64 | 309.19 | 5.46817112 | 3.6641E-05 | -0.1136697 | 3.6641E-05 | -7.269E-08 | 0.025 | 27292.0819 | 0.6640625 | |
| 14 | 310.64 | 309.18 | 5.96197319 | 3.6664E-05 | -0.1148855 | 3.6664E-05 | -7.352E-08 | 0.025 | 27275.0156 | 0.76171875 | |
| 15 | 310.64 | 309.18 | 6.46291876 | 3.6685E-05 | -0.0985955 | 3.6685E-05 | -6.313E-08 | 0.025 | 27258.7437 | 0.68359375 | |
| 16 | 310.64 | 309.18 | 6.95630217 | 3.6694E-05 | -0.0480589 | 3.6694E-05 | -3.078E-08 | 0.025 | 27252.5548 | 0.5859375 | |
| 17 | 310.63 | 309.18 | 7.44853163 | 3.6683E-05 | 0.02141264 | 3.6683E-05 | 1.3709E-08 | 0.025 | 27260.2278 | 0.68359375 | |
| 18 | 310.63 | 309.18 | 7.93955326 | 3.6666E-05 | 0.07209777 | 3.6666E-05 | 4.6139E-08 | 0.025 | 27272.9643 | 0.76171875 | |
| 19 | 310.63 | 309.18 | 8.4352622 | 3.6659E-05 | 0.08077552 | 3.6659E-05 | 5.1682E-08 | 0.025 | 27278.5018 | 0.60546875 | |
| 20 | 310.63 | 309.18 | 8.93040466 | 3.6668E-05 | 0.04889562 | 3.6668E-05 | 3.1292E-08 | 0.025 | 27271.5951 | 0.703125 | |
| 21 | 310.63 | 309.18 | 9.41798639 | 3.6682E-05 | 0.00678238 | 3.6682E-05 | 4.3422E-09 | 0.025 | 27261.5201 | 0.78125 | |
| 22 | 310.63 | 309.18 | 9.91760397 | 3.668E-05 | -0.0139216 | 3.668E-05 | -8.912E-09 | 0.025 | 27263.0613 | 0.72265625 | |
| 23 | 310.63 | 309.18 | 10.417264 | 3.6648E-05 | 0.01034091 | 3.6648E-05 | 6.6144E-09 | 0.025 | 27286.5226 | 0.76171875 | |
| 24 | 310.63 | 309.18 | 10.916976 | 3.6595E-05 | 0.07801612 | 3.6595E-05 | 4.9829E-08 | 0.025 | 27326.0315 | 0.68359375 | |
| 25 | 310.63 | 309.18 | 11.4183574 | 3.654E-05 | 0.17115429 | 3.6539E-05 | 1.0915E-07 | 0.025 | 27367.5214 | 0.83984375 | |
| 26 | 310.63 | 309.18 | 11.9150991 | 3.6507E-05 | 0.25488386 | 3.6507E-05 | 1.6241E-07 | 0.025 | 27391.6597 | 0.546875 | |

**Figure LuH_20:** Data file structure for data relevant to Figure 4c of the Nature 2023 (LuH) Paper. **Top:** Screenshot of the **published Data** file **Fig.4_Heat Capacity_Data.csv** provided by Respondent to the Investigation Committee. This file is also available on the Zenodo repository (as part of **ReddMatter Data.zip)**.[304] A source data file on the Nature website contains the same datasets. In the **published data** file, only two columns containing a Temperature (T) and a specific heat capacity (C) series are provided for each pressure state. **Bottom:** Screenshot of the **sequestered data** file **9-28-21 cryo/cooldown.csv** for the curve at 20 kbar.**[305]** The **sequestered data** file structure contains 10 columns, including *Time* and *Voltage* series and one additional column labeled *heat capacity*. Furthermore, the temperature series for the 20 kbar curve in the **published data** file is identical to the first 18,050 values of the temperature series in the **sequestered data** file.

[304] Figure 4 Heat Capacity Data (on file as Fig.4_Heat Capacity_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1, and https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-023-05742-0/MediaObjects/41586_2023_5742_MOESM8_ESM.csv.

[305] Sequestered cool down data (on file as coolDown.csv) (collected by Interviewee 3 and originally saved in the sequestered hard drive, under folder "Heat Capacity," subfolder "9-28-21 cryo").

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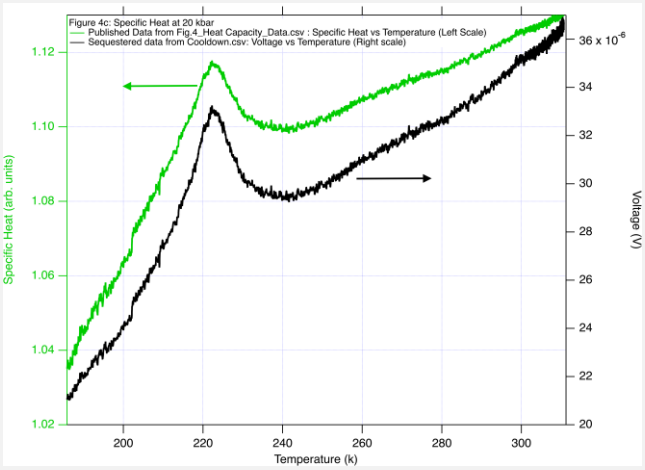


**Figure LuH_21: Analysis by the Investigation Committee:** Comparison of the **published data** and **sequestered data** for the specific heat capacity (C(T)) curve at 20 kbar in Figure 4c of the Nature 2023 (LuH) Paper. The green curve (relative to the left scale) represents the **heat capacity** vs temperature series from the **published data** file. The black curve (relative to the right scale) represents the **measured voltage** vs temperature series from the **sequestered data** file (*see* **Figure LuH_20)**. The strong similarities in the noise patterns between these two curves (which also share a common temperature series) strongly indicate that the **published data** were derived from the **sequestered data**. However, the heat capacity should be proportional to 1/Voltage, which indicates that the **published data** were manipulated to exhibit the expected signature of a bulk superconducting transition (positive jump of C(T) upon cooling).

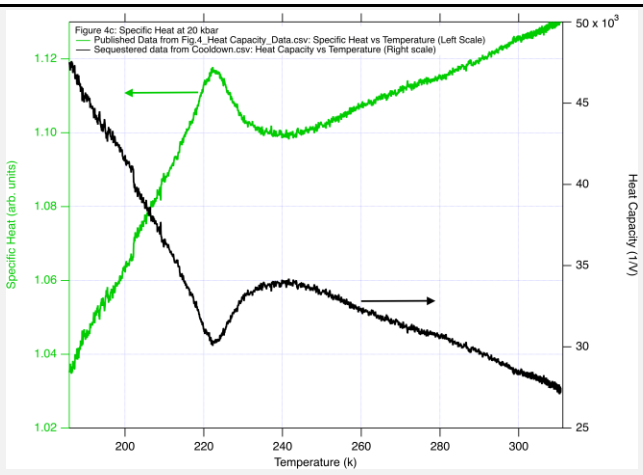


**Figure LuH_22: Analysis by the Investigation Committee:** Comparison of the **published data** and **sequestered data** for the heat capacity (C(T)) curve at 20 kbar in Figure 4c of the Nature 2023 (LuH) Paper. Here we show the **heat capacity** vs temperature series from both the **published data** file (green, same curve as on **Figure LuH_21**) and the **sequestered data** file (black). Strong similarities in the noise patterns between these two curves (which also share a common temperature series) strongly indicate that the **published data** were derived from the **sequestered data. However, the striking difference in temperature dependence behavior between** the **published data** file (green) and the **sequestered data** file (black) indicates that the **published data** were manipulated to exhibit the expected signature of a bulk superconducting transition (positive jump of C(T) upon cooling).

Evidence:

- Several co-authors reached out to *Nature* editors to raise concerns about the C(T) data.[306]
- Respondent provided the file Fig.4_Heat Capacity_Data.csv to the Investigation Committee. This file also is available on the Zenodo repository (as part of ReddMatter Data.zip).[307] A source data file on the *Nature* website contains the same datasets which correspond to the data shown in **Figure 4c** of the Nature 2023 (LuH) Paper. This data file (later referred to as the "published data") only contains two columns, temperature (T) and specific heat capacity (C), for each pressure state.[308]
- Former members of Respondent's laboratory who were directly involved in the collection of the data at issue assisted the Investigation Committee in locating relevant files within sequestered materials. Through this process, the Investigation Committee obtained a data file from the sequestered hard drives from Respondent's laboratory (later referred to as the "sequestered data"), which appears to contain the original (unaltered) data used to prepare **Figure 4c** of the Nature 2023 (LuH) Paper.
    - The sequestered data file contains 10 data columns (in contrast to the published data file), including *time* and *voltage* series and one additional column labeled *heat capacity*. The data span the full range of temperatures from cryogenic (10-50 K) to room temperature (300 K), both during cooling and warming.
    - Analysis by the Investigation Committee reveals strong similarities (including noise patterns) between the data in these two files and identical temperature series which demonstrate that the published data for **Figure 4c** were derived from the sequestered data files collected by Interviewee 3 and saved on Respondent's sequestered laboratory computers (file named cooldown.csv).[309, 310] Further, the raw specific heat capacity data (which exhibit a drop in specific heat upon cooling) were grossly manipulated to create curves exhibiting the expected behavior of a bulk superconducting transition—*i.e.*, having a positive specific heat anomaly.[311, 312] The specific heat series in the published data files appear similar to the measured voltage series in the sequestered data files,

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[306] *See* Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023); *see also* Investigation Committee, *Detailed examination of LuH Specific Heat data and published figures* (Dec. 22, 2023) (on file as LuH_C.pdf) (Investigation Committee's analysis of the specific heat data).

[307] Figure 4 Heat Capacity Data (on file as Fig.4_Heat Capacity_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1, and https://static-content.springer.com/esm/art%3A10.1038%2Fs41586-023-05742-0/MediaObjects/41586_2023_5742_MOESM8_ESM.csv.

[308] *See* Figure LuH_20, above.

[309] *See* Figures LuH_20–22, above.

[310] Sequestered cool down data (on file as coolDown.csv) (collected by Interviewee 3 and saved on Respondent's laboratory computer as coolDown.csv in folder titled Public/red matter CV NDG, to which the Investigation Committee obtained access via a sequestered hard drive containing a folder "Heat Capacity," subfolder "9-28-21 cryo").

[311] *See* Figure LuH_22.

[312] Investigation Committee, *Detailed examination of LuH Specific Heat data and published figures* (Nov. 9, 2023) (on file as LuH_C.pdf) (Investigation Committee's analysis of the specific heat data).

instead of being similar to the specific heat/heat capacity (which is the inverse of the measured voltage).

- Respondent had knowledge that—for the experiments reported in **Figure 4c**—the *heat capacity* is inversely proportional to the measured voltage:
  - Inspection of the data in file cooldown.csv reveals that the *heat capacity* series was computed as the inverse of the *voltage* series.[313]
  - Inspection of the LabVIEW program lock in+current source heat capacity.vi that was likely used to obtain file cooldown.csv reveals that the heat capacity column is computed as 1/Voltage.[314]
  - The methods section of the Nature 2023 (LuH) Paper describes the relationship between the measured voltage and the heat capacity: "The heat capacity is then inversely proportional to the measured voltage."
  - The two former students in Respondent's laboratory who were in charge of developing heat capacity measurements contributed to the document shared with the *Nature* editors, which highlighted that the heat capacity should be inversely proportional to the measured voltage.[315]
  - Respondent co-authored a technical paper describing heat capacity measurements published on arXiv in June 2022,[316] which includes the formula C~1/Voltage LuH. This is evidence of Respondent's knowledge that—for the experiments reported in Figure 4c—the *heat capacity* is inversely proportional to the measured voltage.
- Multiple sources of evidence reveal that Respondent was solely responsible for preparing the figures for the Nature 2023 (LuH) paper.[317]

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Figure 4c** of the Nature 2023 (LuH) Paper, despite all measurements from which the figure was derived having been conducted at the University in Respondent's laboratory. Instead, the evidence reviewed demonstrates that Respondent provided falsified and/or fabricated data to the public as "source data" accompanying the paper and on Zenodo repository. Comparison of the published figures and data obtained from Respondent (also available from Zenodo and the Nature website) with data obtained from the sequestered hard drives from Respondent's laboratory reveals profuse data manipulation, including reporting the inverse of the specific heat (*i.e.*, the voltage) as the measured specific heat. These acts were performed with the apparent aim of producing a signal

[313] *Id*.
[314] *Id*.
[315] *See* Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4 *Concerns with Nature 615, 244-250* (Aug 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023).
[316] Nathan Dasenbrock-Gammon, Raymond McBride, Gyeongjae Yoo, Sachith Dissanayake & Ranga Dias, *Second harmonic AC calorimetry technique within a diamond anvil cell*, ARXIV (Jun. 21, 2022), https://arxiv.org/abs/2206.10072.
[317] *See* evidence presented at the top of this Section III.D.

with the expected signature of a bulk superconducting transition (positive jump of C(T) upon cooling). Respondent had knowledge of the inverse scaling between the measured voltage and the heat capacity, yet intentionally prepared figures suggestive of evidence for a superconducting transition in LuH despite the raw measurements clearly displaying the opposite behavior.

Conclusion:

Taken together, the evidence strongly indicates that Respondent committed intentional data falsification and/or fabrication of the C(T) data displayed in **Figure 4c** of the Nature 2023 (LuH) Paper—a significant departure from accepted practices in the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation D.4** constitutes research misconduct.

**5. Fabrication and/or falsification of Figure 3a, M(T) data (magnetic moment as a function of temperature) under conditions of zero field cooling ("ZFC") and field cooling ("FC")**

Context:

One of the key properties of superconducting materials is to exhibit strong diamagnetism at any temperature below the critical temperature ($T_c$), which corresponds to the temperature at which—upon warming—the material recovers normal, finite electrical resistance. Accordingly, demonstrating strongly diamagnetic behavior is usually required to support, convincingly, a claim of superconducting behavior in technical publications.

The magnetization acquired by a diamagnetic material in response to an applied magnetic field is opposite to the applied field and, therefore, has a ***negative*** sign. This contrasts with the behavior of paramagnetic and ferromagnetic systems which develop a magnetization which is aligned with the applied field and, therefore, has a ***positive*** sign.

**Figure 3a** of the Nature 2023 (LuH) Paper reports PPMS magnetization data as a function of temperature. As published, these data strongly suggest that LuH exhibits diamagnetism (*i.e.*, the Meissner effect): the magnetization of the sample is negative, and its absolute value suddenly increases when it is cooled below a critical temperature near 277 K with an applied magnetic field of 60 Oe at 8 kbar (black curve labeled FC). Taken at face value, this behavior provides compelling evidence to support the claim that LuH exhibits superconductivity at room temperature near 10 kbar. In addition, magnetic hysteresis is observed: a stronger diamagnetic response is obtained when the sample is cooled below the same critical temperature near 277 K in the absence of a magnetic field (red curve labeled ZFC). This demonstrates strong shielding behavior. Note that the absolute value of the ZFC magnetization is greater than the FC magnetization, as expected for a superconductor.

Because the PPMS instrument is a commercial, user-friendly, and commonly available system, it is considered a reliable reference in the superconductivity research field. The reported PPMS data were, therefore, key to convince co-authors and *Nature* referees and editors that LuH exhibits genuine room-temperature superconducting behavior under a modest pressure of ~10 kbar—a very remarkable claim.

***CONFIDENTIAL***

Figures for Reference:

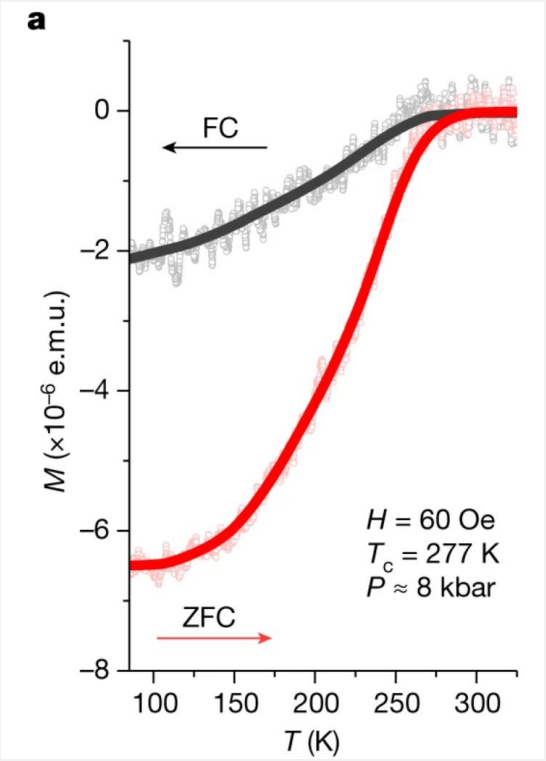


Figure 3a from the Nature 2023 (LuH) Paper reporting the PPMS data ZFC and FC M(T).

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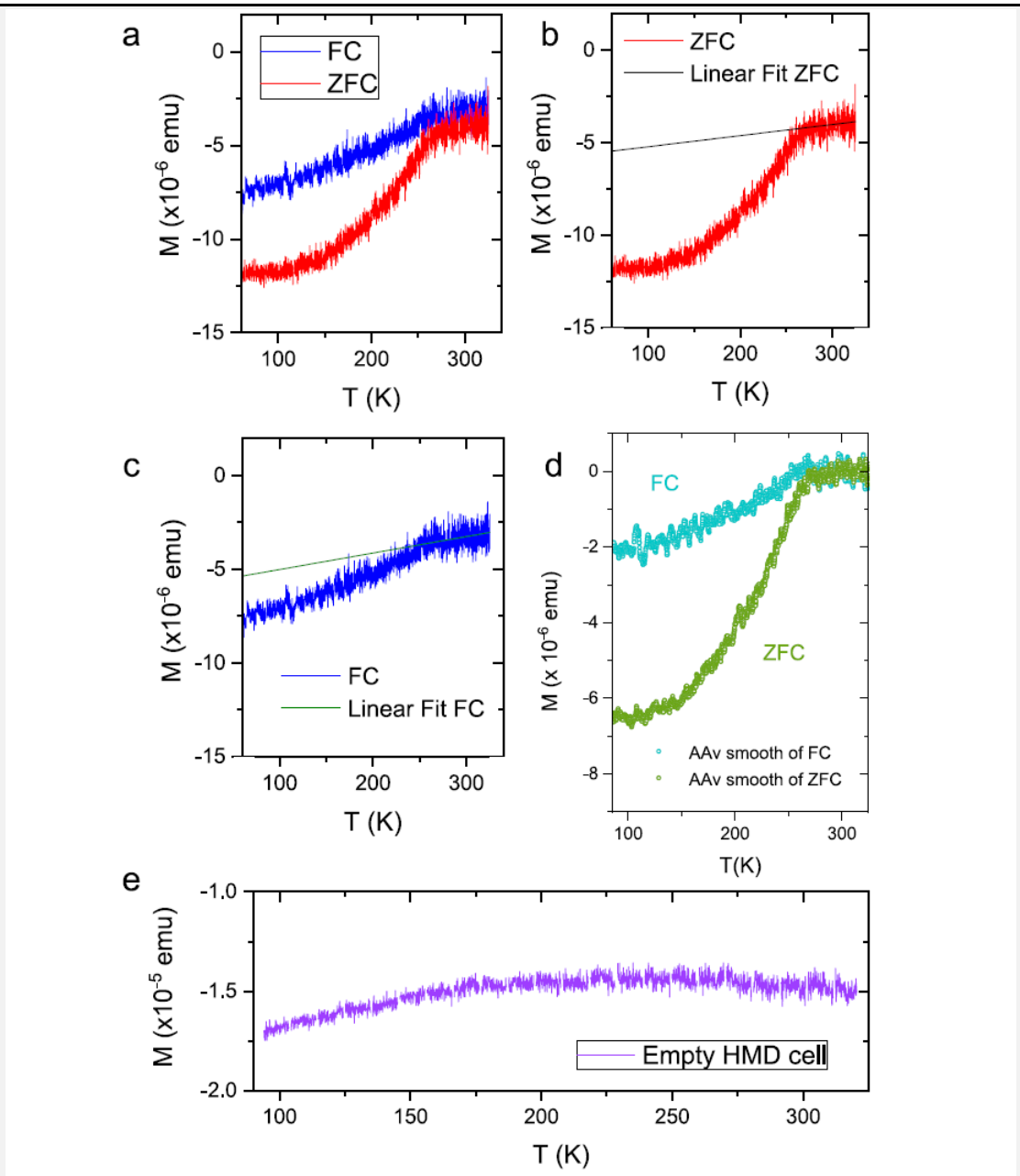


**Extended Data Fig. 14 | Magnetic-susceptibility background and smoothing. a–c**, The ZFC and FC magnetization versus temperature at 8 kbar used to construct Fig. 3a, along with a linear fit to the data at temperatures above the transition temperature, which was used for the background subtraction. **d**, The ZFC and FC curves with the linear backgrounds shown in **b** and **c** subtracted out, as well as with a ten-point adjacent-average smoothing applied. **e**, The measured cell background at 60 Oe for the HMD cell used for the d.c. measurements.

Extended Data Figure 14 from the Nature 2023 (LuH) Paper reporting the ZFC and FC curves.

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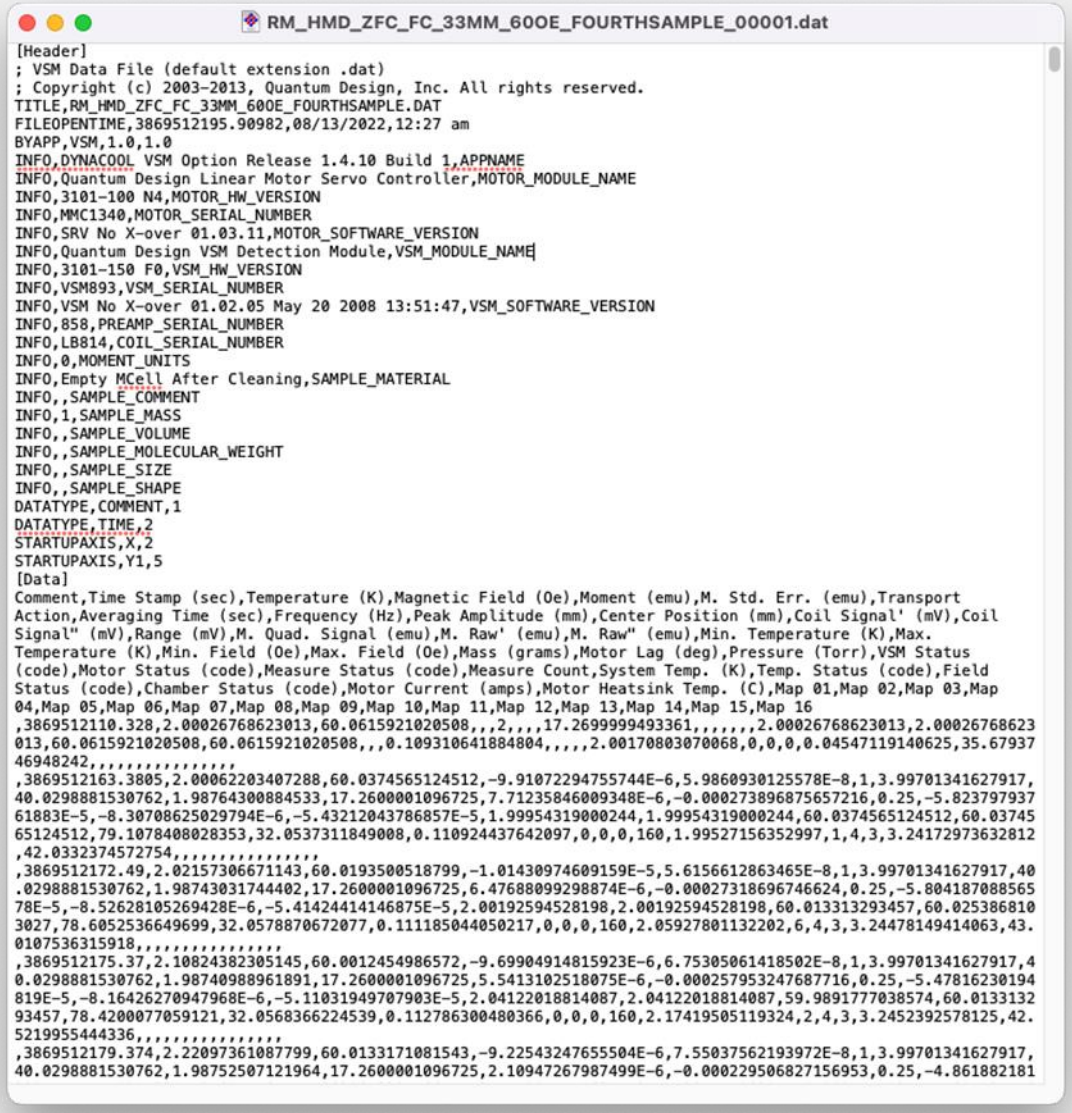


**Figure LuH_23:** Screenshot of one of the sequestered data files containing the raw experimental data relevant to Figure 3a of the Nature 2023 (LuH) Paper. The data file structure includes multiple columns and metadata. This differs significantly from the data file structure exhibited in the **published data** file Fig.3 and EDF14_DC_magnatization_Data.csv shared by Respondent with the Investigation Committee and on the Zenodo repository.[318]

[318] Figure 3 and Extended Data Figure 14 magnetization data (on file as Fig.3 and EDF14_DC_magnatization_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1.

***CONFIDENTIAL***

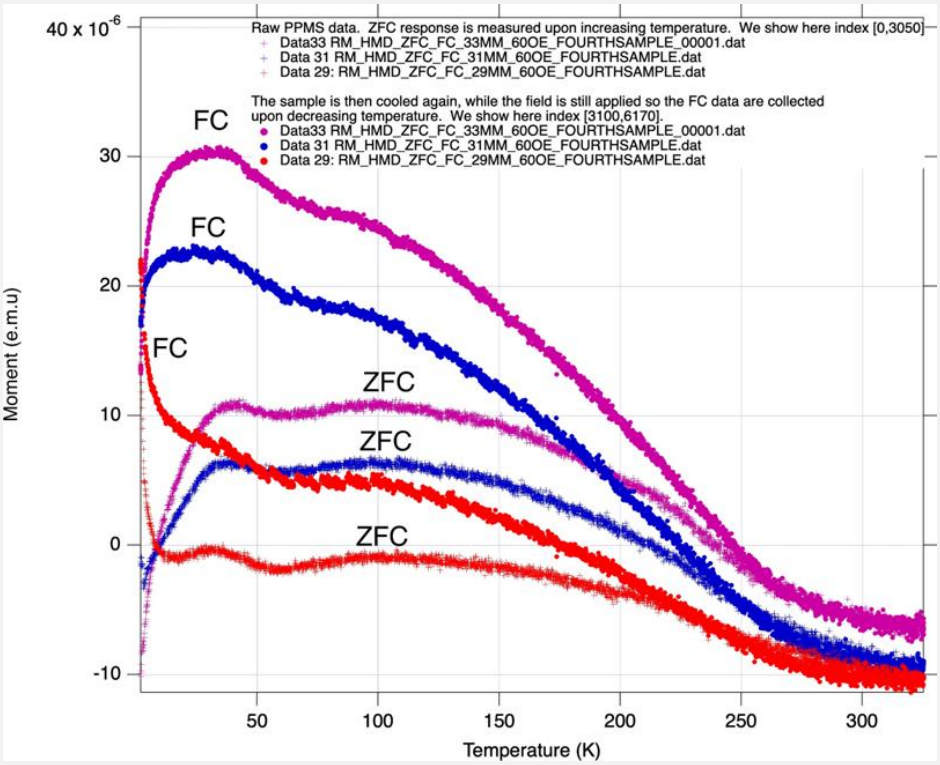


**Figure LuH_24: Analysis by the Investigation Committee:** sequestered data relevant to Figure 3a of the Nature 2023 (LuH) Paper. The raw magnetization data measured upon FC and ZFC conditions for 3 different positions of the sample at 29, 31 and 33 mm reveals a **positive** magnetization in contrast to the **negative** magnetization reported in Figure 3a of the Nature 2023 (LuH) Paper. Data at 33 mm correspond to the sample almost perfectly centered between the pick-up coils and contains the largest signal contribution from the sample, while curves at 29 and 31 mm contain a smaller signal contribution from the sample and a larger contribution from the cell and sample environment.

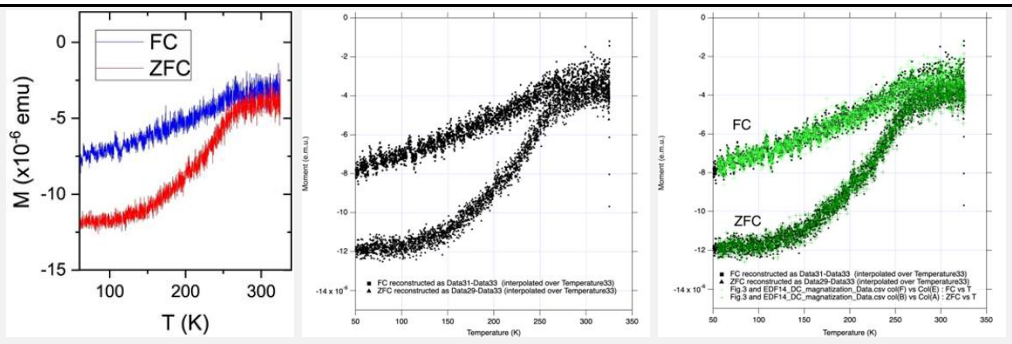


**Figure LuH_25: Analysis by the Investigation Committee:** ZFC and FC magnetization curves published in Figure 3a of the Nature 2023 (LuH) Paper. **Left:** Copy of Extended Figure 14a which reports the ZFC and FC measurements before smoothing and background subtraction. **Center:** ZFC and FC curves reconstructed by the Investigation Committee using the **sequestered data** and the **erroneous method** used by Respondent to fabricate the curves for Figure 3a. Specifically, IgorPro was used to: (1) read the sequestered data files; (2) load datasets at 29, 31 and 33 mm; (3) separate each into ZFC and FC sections; (4) interpolate each of the 31 mm and 29 mm sections onto the temperature series of the corresponding 33 mm section; and (5) create the ZFC and FC curves as: ZFC= ZFC[29mm] -ZFC[33mm] and FC= FC[31mm] - FC[33mm]. **Right:** The published data (green) overlaid onto the reconstructed curves (black). The excellent match, including noise patterns near 100 K for the FC curve and 200 K for the ZFC curve, demonstrates that Respondent fabricated ZFC and FC signals to provide false evidence of the expected behavior for a superconducting transition near 250 K, by essentially reversing the sign of the measured signal.

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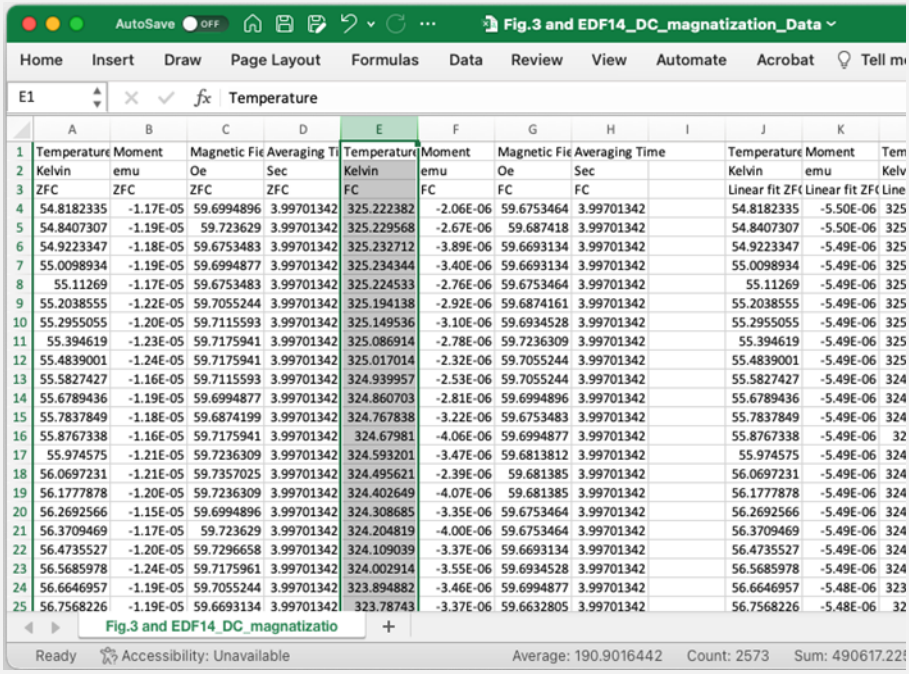

Fig.3 and EDF14_DC_magnatization_Data

| | A | B | C | D | E | F | G | H | I | J | K | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Temperature | Moment | Magnetic Fie | Averaging Ti | Temperature | Moment | Magnetic Fie | Averaging Time | | Temperature | Moment | Tem |
| 2 | Kelvin | emu | Oe | Sec | Kelvin | emu | Oe | Sec | | Kelvin | emu | Kelv |
| 3 | ZFC | ZFC | ZFC | ZFC | FC | FC | FC | FC | | Linear fit ZFC | Linear fit ZFC | Line |
| 4 | 54.8182335 | -1.17E-05 | 59.6994896 | 3.99701342 | 325.222382 | -2.06E-06 | 59.6753464 | 3.99701342 | | 54.8182335 | -5.50E-06 | 325 |
| 5 | 54.8407307 | -1.19E-05 | 59.723629 | 3.99701342 | 325.229568 | -2.67E-06 | 59.687418 | 3.99701342 | | 54.8407307 | -5.50E-06 | 325 |
| 6 | 54.9223347 | -1.18E-05 | 59.6753483 | 3.99701342 | 325.232712 | -3.89E-06 | 59.6693134 | 3.99701342 | | 54.9223347 | -5.49E-06 | 325 |
| 7 | 55.0098934 | -1.19E-05 | 59.6994877 | 3.99701342 | 325.234344 | -3.40E-06 | 59.6693134 | 3.99701342 | | 55.0098934 | -5.49E-06 | 325 |
| 8 | 55.11269 | -1.17E-05 | 59.6753483 | 3.99701342 | 325.224533 | -2.76E-06 | 59.6753464 | 3.99701342 | | 55.11269 | -5.49E-06 | 325 |
| 9 | 55.2038555 | -1.22E-05 | 59.7055244 | 3.99701342 | 325.194138 | -2.92E-06 | 59.6874161 | 3.99701342 | | 55.2038555 | -5.49E-06 | 325 |
| 10 | 55.2955055 | -1.20E-05 | 59.7115593 | 3.99701342 | 325.149536 | -3.10E-06 | 59.6934528 | 3.99701342 | | 55.2955055 | -5.49E-06 | 325 |
| 11 | 55.394619 | -1.23E-05 | 59.7175941 | 3.99701342 | 325.086914 | -2.78E-06 | 59.7236309 | 3.99701342 | | 55.394619 | -5.49E-06 | 325 |
| 12 | 55.4839001 | -1.24E-05 | 59.7175941 | 3.99701342 | 325.017014 | -2.32E-06 | 59.7055244 | 3.99701342 | | 55.4839001 | -5.49E-06 | 325 |
| 13 | 55.5827427 | -1.16E-05 | 59.7115593 | 3.99701342 | 324.939957 | -2.53E-06 | 59.7055244 | 3.99701342 | | 55.5827427 | -5.49E-06 | 324 |
| 14 | 55.6789436 | -1.19E-05 | 59.6994877 | 3.99701342 | 324.860703 | -2.81E-06 | 59.6994896 | 3.99701342 | | 55.6789436 | -5.49E-06 | 324 |
| 15 | 55.7837849 | -1.18E-05 | 59.6874199 | 3.99701342 | 324.767838 | -3.22E-06 | 59.6753483 | 3.99701342 | | 55.7837849 | -5.49E-06 | 324 |
| 16 | 55.8767338 | -1.16E-05 | 59.7175941 | 3.99701342 | 324.67981 | -4.06E-06 | 59.6994877 | 3.99701342 | | 55.8767338 | -5.49E-06 | 32 |
| 17 | 55.974575 | -1.21E-05 | 59.7236309 | 3.99701342 | 324.593201 | -3.47E-06 | 59.6813812 | 3.99701342 | | 55.974575 | -5.49E-06 | 324 |
| 18 | 56.0697231 | -1.21E-05 | 59.7357025 | 3.99701342 | 324.495621 | -2.39E-06 | 59.681385 | 3.99701342 | | 56.0697231 | -5.49E-06 | 324 |
| 19 | 56.1777878 | -1.20E-05 | 59.7236309 | 3.99701342 | 324.402649 | -4.07E-06 | 59.681385 | 3.99701342 | | 56.1777878 | -5.49E-06 | 324 |
| 20 | 56.2692566 | -1.15E-05 | 59.6994896 | 3.99701342 | 324.308685 | -3.35E-06 | 59.6753464 | 3.99701342 | | 56.2692566 | -5.49E-06 | 324 |
| 21 | 56.3709469 | -1.17E-05 | 59.723629 | 3.99701342 | 324.204819 | -4.00E-06 | 59.6753464 | 3.99701342 | | 56.3709469 | -5.49E-06 | 324 |
| 22 | 56.4735527 | -1.20E-05 | 59.7296658 | 3.99701342 | 324.109039 | -3.37E-06 | 59.6693134 | 3.99701342 | | 56.4735527 | -5.49E-06 | 324 |
| 23 | 56.5685978 | -1.24E-05 | 59.7175961 | 3.99701342 | 324.002914 | -3.55E-06 | 59.6934528 | 3.99701342 | | 56.5685978 | -5.49E-06 | 324 |
| 24 | 56.6646957 | -1.19E-05 | 59.7055244 | 3.99701342 | 323.894882 | -3.46E-06 | 59.6994877 | 3.99701342 | | 56.6646957 | -5.48E-06 | 323 |
| 25 | 56.7568226 | -1.19E-05 | 59.6693134 | 3.99701342 | 323.78743 | -3.37E-06 | 59.6632805 | 3.99701342 | | 56.7568226 | -5.48E-06 | 32 |

Fig.3 and EDF14_DC_magnatizatio

Ready Accessibility: Unavailable Average: 190.9016442 Count: 2573 Sum: 490617.225

Table9:Temperature__K_,Temperature__K_,Temperature__K_,Temperature__K_,...

Unused

| Point | Temperature__K_ | Temperature__K_ | Temperature__K_ | Temperature__K_ | Temperature__K_ |
|---|---|---|---|---|---|
| 3101 | 325.192459 | 325.21524 | 325.222382 | 325.171356 | 325.241623 |
| 3102 | 325.159302 | 325.197952 | 325.229568 | 325.176941 | 325.244034 |
| 3103 | 325.107224 | 325.164673 | 325.232712 | 325.181763 | 325.23288 |
| 3104 | 325.042831 | 325.10466 | 325.234344 | 325.187103 | 325.201462 |
| 3105 | 324.963348 | 325.043396 | 325.224533 | 325.220093 | 325.154007 |
| 3106 | 324.888535 | 324.964645 | 325.194138 | 325.22702 | 325.092102 |
| 3107 | 324.801529 | 324.890945 | 325.149536 | 325.230545 | 325.024445 |
| 3108 | 324.712997 | 324.805618 | 325.086914 | 325.231125 | 324.949081 |
| 3109 | 324.623764 | 324.718185 | 325.017014 | 325.218414 | 324.869293 |
| 3110 | 324.531952 | 324.621063 | 324.939957 | 325.186844 | 324.786041 |
| 3111 | 324.443054 | 324.537079 | 324.860703 | 325.139664 | 324.698547 |
| 3112 | 324.337112 | 324.441437 | 324.767838 | 325.077988 | 324.610733 |
| 3113 | 324.242661 | 324.345932 | 324.67981 | 324.639953 | 324.518814 |
| 3114 | 324.141861 | 324.237915 | 324.593201 | 324.260742 | 324.425659 |
| 3115 | 324.041321 | 324.139389 | 324.495621 | 324.247604 | 324.326569 |
| 3116 | 323.926926 | 324.033981 | 324.402649 | 324.182053 | 324.22937 |
| 3117 | 323.824707 | 323.93103 | 324.308685 | 324.08374 | 324.128036 |
| 3118 | 323.692703 | 323.829056 | 324.204819 | 323.981461 | 324.030273 |
| 3119 | 323.566971 | 323.703278 | 324.109039 | 323.877106 | 323.917419 |
| 3120 | 323.436401 | 323.563431 | 324.002914 | 323.76564 | 323.80452 |
| 3121 | 323.281296 | 323.427338 | 323.894882 | 323.641083 | 323.675018 |

**Figure LuH_26: Analysis by the Investigation Committee:** Comparison of the **published** and **sequestered data** files for the ZFC and FC magnetization curves relevant to Figure 3a of the Nature 2023 (LuH) Paper. **Top:** Screenshot of the **published data** file **Fig.3 and EDF14_DC_magnatization_Data.csv,** visualized with Excel. The *Temperature series* for the FC data shown in Figure 3a is highlighted. **Bottom:** Corresponding *Temperature* series from the **sequestered data** files. From left to right, columns correspond to the measurements at various positions: 29 mm, 30 mm, 31 mm, 32 mm, and 33 mm, respectively. Comparing these series reveals a match (to 9 digits) between the highlighted *Temperature series* in the **published data** file (Top, fifth column from the left) and the *Temperature* series in the **sequestered data** file for the FC measurements at 31 mm (bottom, fourth column from the left). Because random temperature fluctuations and data acquisition noise will make each temperature series very slightly different, a perfect match to 9 digits over a large series of 2,570 points demonstrates unambiguously that the **published FC** data are derived from the **sequestered data**.

Evidence:

- VSM measurement with a PPMS instrument is a well-established technique, which includes collecting several M(T) or M(H) curves—with or without applied magnetic field—with the sample positioned at various distances from the pick-up coils. The closer the sample to the mid-point between the pick-up coils, the higher the contribution of the sample to the measured signal.[319]
- The data file relevant to **Figure 3a** of the Nature 2023 (LuH) Paper that was shared by Respondent with the Investigation Committee and on the Zenodo repository is Fig.3 and EDF14 DC magnatization Data.csv (later referred to as the "published data"). This file contains two groups (ZFC and FC) of six-column datasets, including *temperature*, *moment*, and a *background* series. Analysis by the Investigation Committee confirms that the data in the published data file were used to prepare **Figure 3** and **Extended Data Figure 14** of the Nature 2023 (LuH) Paper.
- Former members of Respondent's laboratory who were directly involved in the collection of the data at issue assisted the Investigation Committee in locating relevant files within the sequestered materials. During this process, the Investigation Committee obtained the raw, original data from the sequestered hard drive of the computer controlling the PPMS instrument in Respondent's laboratory. Raw data files generated from the PPMS instrument in VSM contain more than 10 columns and additional metadata in an extensive header.[320]
- The PPMS data were collected by Interviewee 4 in Respondent's Laboratory, using the same sample labeled "Fourth Sample" and saved in the native format of the PPMS used in VSM mode. Figure LuH_24, above, displays screenshots of a few examples of sequestered data files from the original measurement files upon FC and ZFC conditions for three different positions of the sample at 29, 31, and 33 mm.[321] These original PPMS data files include both FC and ZFC data because these are collected in sequence. First, the sample is cooled without a field applied before the recording begins. Then, a 60 Oe magnetic field is applied and the ZFC magnetization is measured upon increasing temperature. This corresponds roughly to indices [0,3050].[322] The sample is then cooled again while the field is still applied so the FC data are collected upon decreasing temperature. Figure LuH_24, above, shows index [3100,6170] (filled circles).
- Analysis by the Investigation Committee in Figure LuH_24, above, reveals that the raw magnetization ZFC and FC data measured with the sample positioned near the center of the pick-up coil assembly, *i.e.*, near 33 mm, exhibit a ***positive*** magnetization in contrast to the

[319] *See also* Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug. 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023).
[320] *See* Figure LuH_23, above.
[321] Sequestered FC and ZFC 29MM, 31MM, and 33MM data files (on file as RM_HMD_ZFC_FC_29MM_60OE_FOURTHSAMPLE.dat., RM_HMD_ZFC_FC_31MM_60OE_FOURTHSAMPLE.dat, and RM_HMD_ZFC_FC_33MM_60OE_FOURTHSAMPLE_00001.dat).
[322] *See* Figure LuH_24, above.

***negative*** magnetization reported in **Figure 3a** of the Nature 2023 (LuH) Paper. In addition, the amplitude of the ZFC is ***smaller*** than that of FC response in all three curves shown.

- The Investigation Committee obtained a PowerPoint presentation sent to Respondent by Interviewee 4 on August 26, 2022,[323] which explains the erroneous method used by Respondent to fabricate—from the original experimental data—the curves ultimately published in **Figure 3a**: (i) subtract the larger signal at 33 mm from the curve at 29 or 31 mm (essentially inverting the sign and creating the illusion of a diamagnetic response, even though the actual response is paramagnetic or ferromagnetic); (ii) use data at 31 and 33 mm for the FC, which have almost the same amplitude, to fabricate an FC curve with a small absolute value; and (iii) use data at 29 and 33 mm, which have a larger difference, to fabricate a ZFC curve with a larger absolute value. This indicates that Respondent constructed the published data by computing [background – signal] rather than [signal – background], which ***inverted the sign*** of the published curves, again creating the illusion of a diamagnetic response, even though the actual response is paramagnetic or ferromagnetic.

- Figure LuH_25, above, reveals that an excellent match is observed between the published data and ZFC and FC curves reconstructed by the Investigation Committee using the sequestered data and the erroneous method used by Respondent to fabricate the curves for **Figure 3a** from the sequestered data.

- Comparison of the temperature series for the FC curves[324] provides further evidence that the published data were derived from the sequestered data obtained by the Investigation Committee. This comparison reveals a match to nine digits between the highlighted temperature series in the published dataset[325] (Figure LuH_26, above, top image, fifth column from the left) and the temperature series in the raw data file for the FC measurements at 31 mm.[326] Because random temperature fluctuations and data acquisition noise will make each temperature series vary slightly differently, a perfect match to nine digits over a large series of 2,570 points demonstrates unambiguously that the FC data published in the paper are derived from the sequestered data obtained by the Investigation Committee.

- The analyses and conclusions of former members of Respondent's laboratory,[327] including those of Interviewee 4, were corroborated by the Investigation Committee.[328] The analysis of these former laboratory members reveals that the published curves were derived from the measurements following the grossly erroneous method, detailed to Respondent in a document

[323] Email from Respondent to Interviewee 4 (Aug. 26, 2023, 4:33pm) (on file as PPMS [PPT embedded in PDF].pdf) (attaching "DC.pptx" which is a PowerPoint consisting of Respondent's PPMS analysis); *see also* Respondent's PPMS analysis (on file as DC.pdf).
[324] *See* Figure LuH_26, above.
[325] *See* Figure LuH_26, above, top image, fifth column from the left.
[326] *See* Figure LuH_26, above, bottom image, fourth column from the left.
[327] *See also* Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug. 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023).
[328] Investigation Committee, *Detailed examination of LuH PPMS data and published figures* (Dec. 22, 2023) (on file as LuH_PPMS.pdf) (Investigation Committee's analysis of the PPMS data).

sent by Interviewee 4 on August 26, 2022.[329, 330] Respondent ignored the concerns and detailed explanations that were sent by Interviewee 4 to Respondent on August 27, 2022,[331, 332] in which Interviewee 4 demonstrated that the analysis method was erroneous.[333]

- Testimonies to the Investigation Committee indicate that Respondent prepared the figures and decided on the interpretation ultimately conveyed in the Nature 2023 (LuH) Paper. Interviewee 4's disagreement is reflected in the author contribution statement of Nature 2023 (LuH) Paper, which lists only Respondent as being responsible for the PPMS data analysis.
- Interviewee 7's testimony indicated that the PPMS data, as presented by Respondent in the manuscript, are what convinced Interviewee 7 of the merit of the data and made the case for superconducting behavior in LuH stronger.[334]
- Email correspondence between Respondent's counsel, Mr. Robert Heist, and *Nature* editors reveals the essential role of the PPMS data in convincing the *Nature* editors that LuH exhibits genuine room-temperature superconducting behavior under a modest pressure of ~10 kbar:

> The authors have confirmed DC susceptibility, M-H Curve, and lower critical field using standard PPMS instrumentation from Quantum Design, Inc. In other words, the authors have proven the Meissner Effect. Coming out of the GRC, this discovery has generated significant interest within the scientific community and the authors are prepared to publish. In light of the feedback provided in the initial peer review of our manuscript by Nature, we want to make a final proposal to allow Nature to publish this most recent discovery in superconductivity.
>
> Although the authors are prepared to continue with an expedited pre-publication peer review process, time is now of the essence and in light of the incontrovertible confirmation of the Meissner Effect by studying the M-H Curve data using PPMS with VSM it should not take more than a few days to validate the updated and revised manuscript.
>
> Within this process and consistent with the current revised and updated manuscript, Nature will have incontrovertible evidence of the Meissner Effect, M-H Curve findings (using standard instrumentation from Quantum Design, Inc.), our raw data, a conflict of interest statement, a data availability statement as well as the chemical compound "recipe". All of this information is contained in the revised and updated manuscript. In light of the leak of our work that was shared exclusively with Nature during the peer review process, the continuation of this process should be expedited. We believe this proposal will resolve all

[329] Respondent's PPMS analysis (on file as DC.pdf).
[330] *See* Email from Respondent to Interviewee 4 (Aug. 26, 2023, 4:33pm) (on file as PPMS [PPT embedded in PDF].pdf) (attaching "DC.pptx" which is a PowerPoint consisting of Respondent's PPMS analysis).
[331] Interviewee 4's PPMS analysis (on file as PPMS 4th Sample data.pdf) (Sent to Respondent on August 27, 2022).
[332] *See* Email from Interviewee 4 to Respondent (Aug. 27, 2022, 11:24am) (on file as PPMS 4th sample my analysis [PPT embedded in PDF].pdf) (attaching the document "PPMS 4th Sample data.pptx" and stating: "I was looking at this whole night and morning. Please see below PPT with my analysis so far.").
[333] Superconductivity is characterized by ZFC(T) and FC(T) curves of negative susceptibility, suddenly increasing towards zero with increasing temperature approaching the critical temperature, and with magnitude of the ZFC(T) curve being greater (more negative) than the FC(T) curve. The falsified data in Figure 3a appears to show that; however, correct analysis of the raw data produces monotonically decreasing curves of positive susceptibility, which are never characteristic of a superconductor.
[334] *See* Interviewee 7 Interview (Oct. 2, 2023) 44:7-45:20.

> of the current questions as well as allow us and Nature to avoid any future adverse considerations.[335]

- A previous email from Respondent's counsel, Mr. Heist, to *Nature* editors includes the following:

> Specifically, the authors have studied magnetization versus field (M-H Curve) data recorded using standard instrumentation (PPMS) utilizing a Vibrating Sample Magnetometer (VSM). As a result, the authors have confirmed DC susceptibility, M-H Curve, and lower critical field using standard PPMS instrumentation from Quantum Design, Inc. In other words, the authors have proven the Meissner Effect and now have advanced superior incontrovertible evidence of superconductivity in their new and different sample. We believe this discovery provides all of us with an opportunity to successfully move beyond the background subtraction methodology utilized with the prior CSH sample which is now nearly two years old while moving into a higher level of incontrovertible proof of a superconducting material that has the very real potential of revolutionizing the modern world.[336]

- To which a *Nature* editor replied:

> We are excited to read that you observed the Meissner effect using a standard PPMS instrument! I recommend that you submit the revised manuscript including the rebuttal to the referees as soon as possible. We don't think that another meeting is necessary at this stage. Given the additional PPMS data and assuming that you addressed the other concerns convincingly, we will send the revised manuscript back to the referees.[337]

- An email dated July 19, 2022 from Respondent's counsel, Mr. Heist, to *Nature* editors includes the following:

> In terms of the incontrovertible evidence supporting our latest reddmatter discovery, we are concerned about the amount of time that your referees may take to recognize the validity of our findings as we anticipate significant interest in publishing our results coming out of the GRC. We understand that you and Karl are both recognized experts in the field of superconductivity. As such, we recognize that the editorial board, yourselves included, possesses the capability to appreciate the impact of confirming the Meissner Effect by studying magnetization versus field (M-H Curve) data recorded using standard instrumentation (PPMS) utilizing a Vibrating Sample Magnetometer (VSM). With your expertise, you are well-positioned to recognize that the authors have confirmed DC susceptibility, M-H Curve, and lower critical field using standard PPMS instrumentation from Quantum Design, Inc. This confirmation should put to rest all of the unrelated observations and comments from the referees and allow the paper to be published without further delay.[338]

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[335] Email from Robert Heist to Tobias Roedel (Jul. 27, 2022, 12:38pm) (on file as 2022.08.01 Email TR.RH.pdf, at pages 3-4) (Email chain obtained through sequestration of Respondent's Box accounts).
[336] Email from Robert Heist to Nature Editorial Board (Jul. 8, 2022, 2:52pm) (on file as 2022.08.01 Email TR.RH.pdf, at page 12) (Email chain obtained through sequestration of Respondent's Box accounts).
[337] *Id*. at 9.
[338] Email from Robert Heist to Tobias Roedel (Jul. 19, 2022, 7:39pm) (on file as 2022.08.01 Email TR.RH.pdf, at page 7) (Email chain obtained through sequestration of Respondent's Box accounts).

- Following a request by the University, Nature provided a copy of the pre-publication peer-review reports for the Nature 2023 (LuH) paper to the Investigation Committee.[339] The first review by Reviewer #2 includes: "I strongly suggest authors to measure their high pressure samples using the widely accepted method based on commercial MPMS or the update version instruments. This is very crucial to support their conclusion." Subsequent reviews include multiple questions and comments regarding these measurements.

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Figure 3a** of the Nature 2023 (LuH) Paper, despite all measurements from which the figure was derived having been conducted at the University in Respondent's laboratory. Instead, the evidence reviewed demonstrates that Respondent provided falsified and/or fabricated data to the Investigation Committee and to the public on the Zenodo repository. Testimony and cooperation from the research faculty member who performed these experiments enabled the Investigation Committee to identify—within sequestered electronic records—a set of raw experimental data files for PPMS measurements on the "Fourth Sample." Detailed analysis by the Investigation Committee demonstrates, unambiguously, that: (1) these files were used to prepare the ZFC and FC curves versus temperature shown in **Figure 3a** of the Nature 2023 (LuH) Paper; (2) the raw experimental data for these PPMS measurements indicate that the sample's true response to an applied magnetic field is clearly positive, such that the LuH samples were, therefore, not superconducting at low temperature;[340] and (3) clear and profuse manipulations were performed to fabricate plausible ZFC and FC curves having characteristics of both the expected superconducting response and of PPMS measurements (*e.g.*, resolution, noise, and temperature series). These acts were performed with the apparent aim of producing a signal with the expected signature of a bulk superconducting transition to convince co-authors and *Nature* referees and editors that LuH exhibits genuine room-temperature superconducting behavior under a modest pressure of ~10 kbar.

Because the PPMS instrument is a commercial product that is widely available and reliable, it has become the de-facto "gold standard" for magnetization and superconductivity research. Taken at face value, the falsified data reported in **Figure 3a**, and their supporting documentation in **Extended Data Figure 14**, provided extraordinarily strong evidence for the referees and *Nature* editors to accept the claim of room temperature superconductivity in LuH after several rounds of review. In their correspondence with *Nature* editors, Respondent and his counsel repeatedly argued that the PPMS data were "incontrovertible evidence of superconductivity" in the sample.[341]

[339] *See* Peer Review Reports for Nature 2023 (LuH) Paper (on file as Dias_2023_peer_review_reports.pdf) (Provided by Nature to Investigation Committee).
[340] A characteristic of a superconductor is to acquire a negative magnetic moment under applied magnetic field—in other words, a superconductor exhibits diamagnetism.
[341] Email from Robert Heist to Tobias Roedel (Jul. 19, 2022, 7:39pm) (on file as 2022.08.01 Email TR.RH.pdf, at page 7) (Email chain obtained through sequestration of Respondent's Box accounts).

Multiple sources (including written correspondence and documentation) indicate that Respondent prepared **Figure 3a** and **Extended Data Figure 14**, and that Respondent decided on their ultimate interpretation as presented in the Nature 2023 (LuH) Paper.[342]

Conclusion:

Taken together, these observations strongly indicate that Respondent intentionally committed data fabrication and/or falsification of the ZFC and FC M(T) data in **Figure 3c** and **Extended Data Figure 14** to convince *Nature* editors and pre-publication referees that LuH exhibits superconductivity at room temperature near 10 kbar. This represents a significant departure from accepted practices within the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to this **Allegation D.5** violates accepted research standards and constitutes research misconduct.

### 6. Fabrication and/or falsification of Figure 3b, M(H) data (magnetic moment as a function of applied magnetic field)

Context:

As discussed above, one of the key properties of a superconducting material is that it exhibits a diamagnetic response at any temperature below the critical temperature ($T_c$).

When reporting the magnetization (M) acquired in response to an applied magnetic field (H), the slope in the M-H plane will be ***negative*** for a diamagnetic response.

**Figure 3b** of the Nature 2023 (LuH) Paper reports several M(H) curves collected at various temperatures from 100 to 275K. As published, these data provide compelling evidence for diamagnetism: the magnetization of the sample is ***negative*** and—at low field—its absolute value increases linearly with increasing applied magnetic field, as expected for a superconductor.

[342] *See, e.g.*, Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug. 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023). *See also* evidence presented at the top of this Section III.D.

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Figures for Reference:

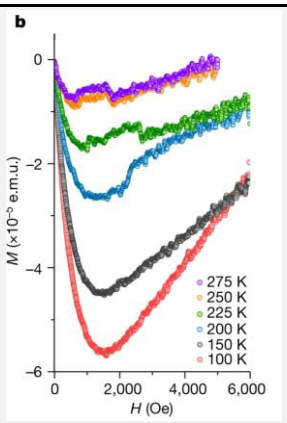


Figure 3b from the Nature 2023 (LuH) Paper reporting the PPMS M(H) data.

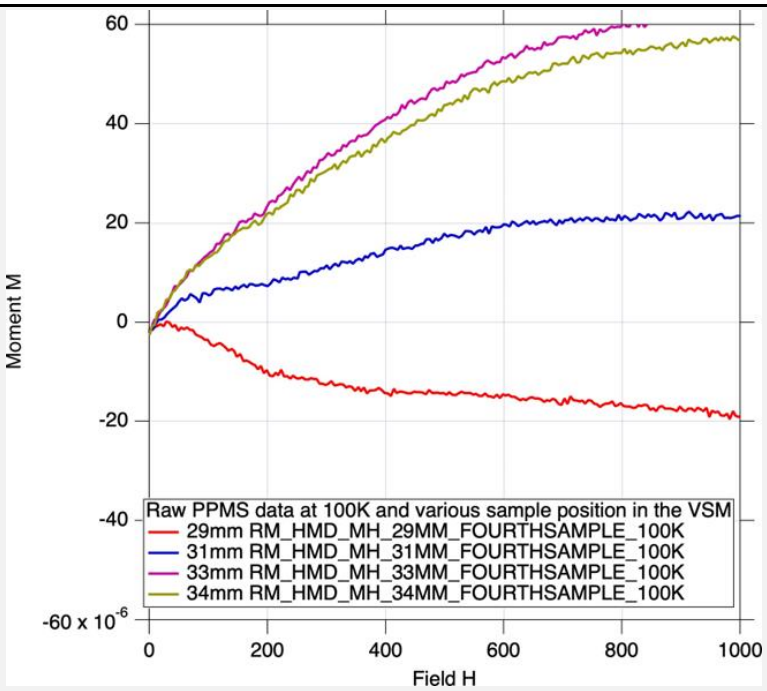


**Figure LuH_27: Analysis by the Investigation Committee using the sequestered data.** Comparison of the M(H) data collected at 100 K with the sample at various positions within the PPMS VSM. The signal is similar at 33 mm and 34 mm, which is expected if both positions correspond to the sample being almost centered between the pick-up coils. In contrast, the curve at 29 mm corresponds to the background. The curves at 33 and 34 mm clearly exhibit a **positive slope**: M increases upon increased applied magnetic field. This is the opposite of the **negative slope**—corresponding to diamagnetic behavior characteristic of a superconducting state—presented in Figure 3b of the Nature 2023 (LuH) Paper.

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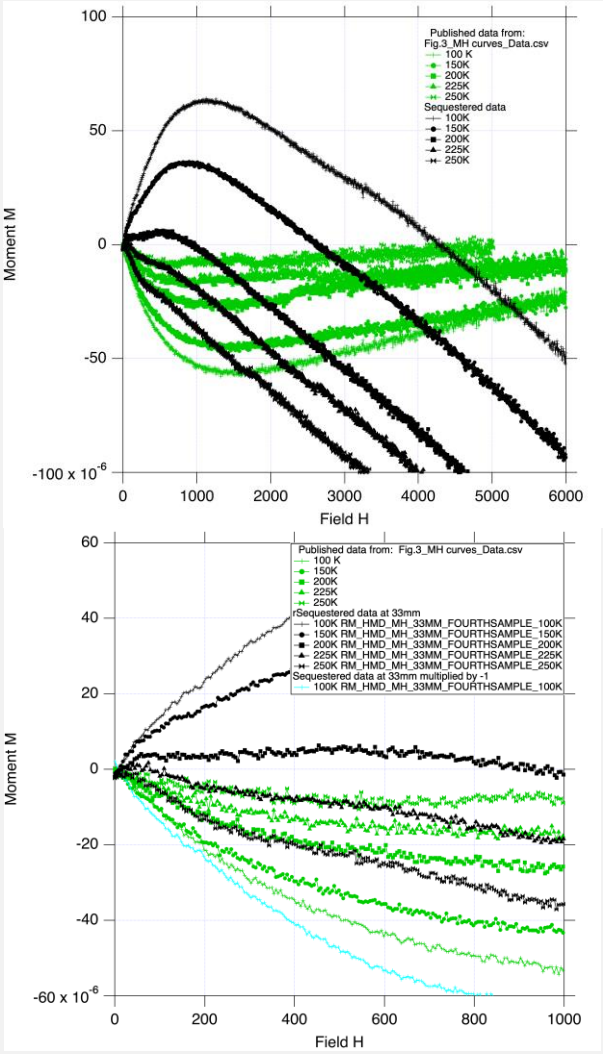


**Figure LuH_28: Analysis by the Investigation Committee: Top:** Comparison of the **published** and **sequestered** data in the range of applied field strengths similar to that in Figure 3b of the Nature 2023 (LuH) Paper. Green curves: data from the **published data** file (Fig.3_MH curves_Data.csv).[343] Black curves: data collected with the sample positioned at 33 mm obtained from the **sequestered data** files.[344] **Bottom:** Expanded view with H < 1000 Oe. The **sequestered data** at 100K and 150 K exhibit a positive slope in the M-H plane, in contrast with the expected behavior for a superconductor and the **published data** (green). Strong similarities in the noise patterns are observed between the **published data** at 100 K and the **sequestered data** at 100 K (cyan).

[343] M(H) curve data (on file as Fig.3_MH curves_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1.

[344] Sequestered data collected at 33MM (on file as RM_HMD_MH_33MM_FOURTHSAMPLE_100K.dat, RM_HMD_MH_33MM_FOURTHSAMPLE_150K.dat, RM_HMD_MH_33MM_FOURTHSAMPLE_200K.dat, RM_HMD_MH_33MM_FOURTHSAMPLE_225K.dat, and RM_HMD_MH_33MM_FOURTHSAMPLE_250K.dat).

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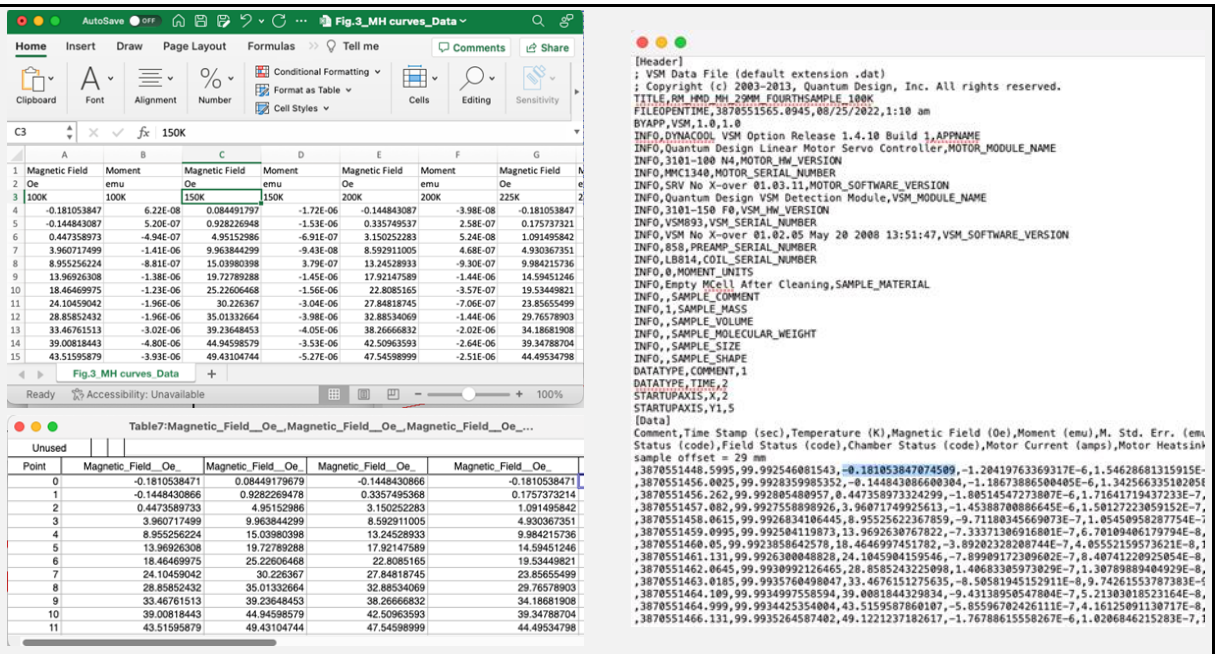

**Figure LuH_29:** Screenshots of the M(H) data files. **Top Left:** published M(H) data shared by Respondent in **Fig.3_MH_curves_Data.csv** visualized with Excel.[345] **Bottom Left:** Corresponding magnetic field series from the **sequestered** data files at 100, 150, 200, and 225 K collected at 29mm. **Right:** screenshot of the sequestered data file **RM_HMD_MH_29MM_FOURTHSAMPLE_100K.dat** opened with TextEdit. Note: a carriage return was inserted after "sample offset = 29mm" for clarity. The first element of the magnetic field series is highlighted in blue and subsequent values can be found in a vertical column. This comparison reveals identical magnetic field series which indicates unambiguously that the **published** data were derived from the **sequestered** data.

Evidence:

- VSM measurements with a PPMS instrument is a well-established technique, which includes collecting several M(T) or M(H) curves—with or without applied magnetic field—with the sample positioned at various distances from the pick-up coils. The closer the sample is to the mid-point between the pick-up coils, the higher the contribution of the sample to the measured signal.
- The data file relevant to **Figure 3b** of the Nature 2023 (LuH) Paper that was shared by Respondent with the Investigation Committee and on the Zenodo repository is Fig.3_MH curves_Data.csv (later referred to as the "published data").[346] This data file contains six two-column (H,M) datasets for the M(H) curves shown in **Figure 3b**. Analysis by the Investigation Committee confirms that the data in the published data file were used to prepare **Figure 3b** of the Nature 2023 (LuH) Paper.
- Former members of Respondent's laboratory who were directly involved in the collection of

[345] M(H) curve data (on file as Fig.3_MH curves_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1.
[346] M(H) curve data (on file as Fig.3_MH curves_Data.csv), *also available at* https://zenodo.org/records/7374510/files/ReddMatter%20Data.zip?download=1.

the data at issue assisted the Investigation Committee in locating relevant files within the sequestered materials. The Investigation Committee obtained the raw, original data from the sequestered hard drive of the computer controlling the PPMS instrument in Respondent's laboratory. Raw data files generated from the PPMS instrument in VSM mode contain more than 10 columns and additional metadata in an extensive header.[347]

- The PPMS data were collected by Interviewee 4 in Respondent's Laboratory, using the same sample labeled "Fourth Sample" and saved in the native format of the PPMS used in VSM mode.
- Analysis by the Investigation Committee in Figures LuH_27 and LuH_28 reveal the sequestered M(H) data at 100 K and 150 K—where the signal is expected to be the least ambiguous—clearly indicate a positive M(H) slope at low field, in stark contrast to the negative slope (diamagnetic response) exhibited by the published data.
- Detailed analysis by the Investigation Committee reveals that the 1,200 values for the magnetic field series reported in file Fig.3_MH curves_Data.csv at 100, 150, 200, and 225 K each match to 10 digits of precision with the values of the magnetic field series for the sequestered data collected at 29 mm.[348] Because random magnetic field fluctuations and data acquisition noise will make each magnetic field series very slightly different, a perfect match to 10 digits over four separate series of 1,200 points demonstrates unambiguously that the published data are derived from the sequestered data obtained at 29 mm.
- As discussed above, in the introductory paragraphs to **Allegation D**, the testimony of Respondent to the Investigation Committee indicates that Respondent prepared the figures and decided on the interpretation ultimately conveyed in the paper. Interviewee 4's disagreement is reflected in the author contribution statement of the Nature 2023 (LuH) Paper, which lists only Respondent as being responsible for the PPMS data analysis.
- As set forth at **Allegation D.6,** Interviewee 7's testimony indicated that the PPMS data, as presented by Respondent in the manuscript, are what convinced Interviewee 7 of the merit of the data and made the case for superconducting behavior in LuH stronger.[349]
- Also as set forth at **Allegation D.6**, email correspondence between Respondent's counsel and *Nature* editors reveals the essential role of the PPMS data in convincing the *Nature* editors that LuH exhibits genuine room-temperature superconducting behavior under a modest pressure of ~10 kbar.

Findings/Reasoning:

To date, Respondent has not provided raw data files used to produce **Figure 3b** of the Nature 2023 (LuH) Paper, despite all measurements from which the figure was derived having been conducted at the University in Respondent's laboratory. Instead, the evidence reviewed demonstrates that Respondent provided falsified and/or fabricated data to the Investigation

[347] *See* Figure LuH_29, above.
[348] *See id.*; *see also* Sequestered data collected at 29MM (on file as RM_HMD_MH_29MM_FOURTHSAMPLE_100K.dat, RM_HMD_MH_29MM_FOURTHSAMPLE_150K.dat, RM_HMD_MH_29MM_FOURTHSAMPLE_200K.dat, RM_HMD_MH_29MM_FOURTHSAMPLE_225K.dat, and RM_HMD_MH_29MM_FOURTHSAMPLE_250K.dat).
[349] *See* Interviewee 7 Interview (Oct. 2, 2023) 44:7-45:20.

Committee and to the public on Zenodo repository. Testimony and cooperation from the research faculty member who performed these experiments enabled the Investigation Committee to identify—within the sequestered electronic records—a set of experimental data files for PPMS measurements on the "Fourth Sample." Detailed analysis by the Investigation Committee demonstrates, unambiguously, that: (1) these files were used to prepare the M(H) curves at various temperatures shown in **Figure 3b** of the Nature 2023 (LuH) Paper; (2) the raw experimental data for these PPMS measurements indicate that the sample's true response to an applied magnetic field clearly is not that of a superconductor; and (3) clear and profuse data manipulations were performed to fabricate plausible M(H) curves having characteristics of both the expected superconducting response and of PPMS measurements (*e.g.*, resolution, noise, and temperature series). These acts were performed with the apparent aim of producing a signal with the expected signature of a bulk superconducting transition to convince co-authors and *Nature* referees and editors that LuH exhibits genuine room-temperature superconducting behavior under a modest pressure of ~10 kbar.

Because the PPMS instrument is a commercial product that is widely available and reliable, it has become the de-facto "gold standard" for magnetization and superconductivity research. Taken at face value, the falsified data reported in **Figure 3b** of the Nature 2023 (LuH) Paper provided extraordinarily strong evidence for the referees and *Nature* editors to have accepted the claim of room temperature superconductivity in LuH after several rounds of review. In their correspondence with *Nature* editors, Respondent and his counsel repeatedly argued that the PPMS data were "incontrovertible evidence of superconductivity" in the sample.[350]

Multiple sources (including written correspondence and documents)[351] indicate that Respondent prepared **Figure 3b**, and that Respondent decided on its ultimate interpretation as presented in the Nature 2023 (LuH) Paper.[352]

Conclusion:

Taken together, these observations strongly indicate that Respondent intentionally committed data fabrication and/or falsification of the M(H) data in **Figure 3b** to convince *Nature* editors and pre-publication referees that LuH exhibits superconductivity at room temperature near 10 kbar. This represents a significant departure from accepted practices within the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation D.6** violated accepted research standards and constitutes research misconduct.

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[350] Email from Robert Heist to Tobias Roedel (Jul. 19, 2022, 7:39pm) (on file as 2022.08.01 Email TR.RH.pdf, at page 7) (Email chain obtained through sequestration of Respondent's Box accounts).
[351] *See, e.g.*, Letter from Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5, Interviewee 4, Keith V. Lawler & Interviewee 7 to Tobias Roedel (Sep. 8, 2023) (on file as Letter to Nature 09-08-2023 Final.pdf); *see also* Interviewee 3, Interviewee 8, Interviewee 6, Interviewee 9, Interviewee 5 & Interviewee 4, *Concerns with Nature 615, 244-250* (Aug 31, 2023) (on file as LuH-N concerns 8-31-2023.pdf) (Document sent to *Nature*, along with the Letter dated September 8, 2023).
[352] *See also* evidence presented at the top of this Section III.D.

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### 7. Fabrication and/or falsification of Figure 1a, $T_c$(P) data (superconducting critical temperature as a function of pressure)

As discussed at **Allegation A.2**, it is expected from condensed matter theory that increasing external pressure can progressively modify the physical properties of a material and progressively enhance the interactions at the microscopic scale that are responsible for the emergence of superconductivity. Accordingly, studies of superconducting materials under high-pressure usually document how the superconducting critical temperature ($T_c$) varies with pressure.

To obtain critical temperature ($T_c$) for a given material at a given pressure requires, first, collecting the temperature dependence of the physical quantity of interest (*e.g.*, R(T)), then—if a superconducting transition is observed—determining the value of the critical temperature ($T_c$) for the particular material at the particular pressure (usually with a well-defined and documented methodology, *e.g.*, to identify inflection points in each R(T) curve).

**Figure 1a** of the Nature 2023 (LuH) Paper reports the evolution of the superconducting critical temperature ($T_c$) as a function of the pressure (P) that was obtained with electrical conductivity measurements (ρ, 17 data points, also referred to as electrical resistivity measurements, or R), alternating current (a.c.) and direct current (d.c.) magnetic susceptibility measurements (χ', 12 and 3 data points, respectively), and specific heat measurements (C, 9 data points).

The collection of 41 data points displayed in **Figure 1a** seemingly provides a significant body of work that exhibits a clear, strong trend of gradually increasing (below 10 kbar), then decreasing (above 10 kbar), $T_c$ with increasing pressure, with very little scatter. Therefore, on its face, **Figure 1a** as published presents compelling evidence to readers that LuH can indeed host superconductivity up to room temperature near 10kbar.

Figures for Reference:

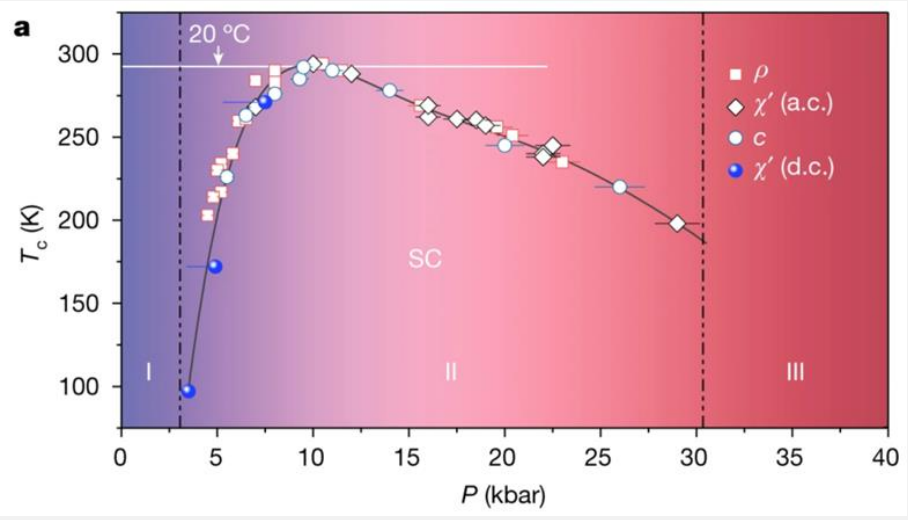


Figure 1a in the Nature 2023 (LuH) Paper, showing the evolution of the critical temperature as a function of applied pressure.

Evidence:

- As discussed earlier in this Section III.D, Respondent was responsible for preparing the figures and the manuscript for the Nature 2023 (LuH) Paper.
- Of the 17 data points in **Figure 1a** of the Nature 2023 (LuH) Paper that are labeled as originating from R(T) measurements (denoted in **Figure 1a** by ρ), Respondent provided only the five warming curves corresponding to measurements published in **Figure 2a**, **Extended Data Figure 13a**, and **Extended Data Figure 15** to the Investigation Committee. This is despite repeated, specific requests (in June and July 2023) from the Investigation Committee for the raw data of the R(T) measurements used to determine each of these 17 $T_c$(P) data points.[353] The Investigation Committee was unable to locate data files underlying any of the remaining 12 $T_c$(P) data points.
- The $T_c$(P) datum labeled as originating from χ' (DC) measurements (blue circle) near 270 K corresponds to the ZFC and FC data shown in Figure 3a of the Nature 2023 (LuH) Paper. As discussed in **Allegation D.5**, these data have been fabricated and/or falsified.
- The $T_c$(P) datum labeled as originating from c measurements (white circle) near 20 kbar and 245 K corresponds to the specific heat capacity data shown in Figure 4c of the Nature 2023 (LuH) Paper. As discussed in **Allegation D.4**, these data have been fabricated and/or falsified.

Findings/Reasoning:

Respondent provided 5 R(T) datasets to the Investigation Committee, from which five of the $T_c$(P) points shown in **Figure 2a, Extended Data Figure 13a**, and **Extended Data Figure 15** could be inferred by the Investigation Committee. However, as explained elsewhere in this report,[354] the Investigation Committee found that those five datasets were more likely than not to have been fabricated and/or falsified. As for the remaining 12 $T_c$(P) points shown in **Figure 1a** of the Nature 2023 (LuH) Paper and attributed to electrical conductivity/resistivity measurements, Respondent has not, to date, provided any credible indication for the existence of the 12 additional R(T) datasets from which those data points may be inferred.

In addition, the $T_c$(P) datum labeled as originating from χ' (DC) measurements (blue circle) near 270 K and $T_c$(P) datum labeled as originating from c measurements (white circle) near 20 kbar and 245 K do not correspond to any actual evidence for a superconducting transition.

Conclusion:

The Investigation Committee's findings indicate that ***all*** $T_c$(P) data points allegedly derived from R(T) data, as well as the $T_c$(P) datum labeled as originating from χ' (DC) measurements near 270 K and the $T_c$(P) datum labeled as originating from c measurements near 20 kbar and 245 K, were fabricated and/or falsified. Other instances of falsification and/or fabrication uncovered by the Investigation Committee regarding the R(T) data presented in this paper and Respondent's inability to produce relevant data for the Investigation Committee's review, strongly indicate that

[353] *See* Exhibit H.
[354] *See* **Allegations D.1, D.2, and D.3**.

Respondent intentionally fabricated and/or falsified these data. Such actions represent a significant departure from accepted practices within the research community.

Accordingly, the Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation D.7** violated accepted research standards and constitutes research misconduct.

## E. NSF Early Career Award Proposal

- **Plagiarism in Respondent's NSF Early Career Award Proposal**

Context:

On August 11, 2020, Respondent submitted a proposal for an NSF Faculty Early Career Development Program award (NSF Proposal Number 2046796 in response to Solicitation Number NSF 20-525).[355] There are duplicative figures and significant overlapping language across this proposal and an arXiv paper by Pant *et al.* submitted on July 30, 2020.[356]

[355] *See* Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf).
[356] *See* Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf); *see also* Anupum Pant, R. Greg Felsted, Alexander B. Bard, Xiaojing Xia, Siamak Dadras, Kamran Shayan, Danika R. Luntz-Martin, Donald Mannikko, Ilia M. Pavlovetc, Stefan Stoll, Masaru Kuno, A. Nick Vamivakas & Peter J. Pauzauskie, *Solid-state laser refrigeration of nanodiamond quantum sensors*, ARXIV (Jul. 30, 2020), https://arxiv.org/abs/2007.15247.

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Figures for Reference:

**i. Debye-Waller Factor (DWF) Thermometry with the Nitrogen Vacancy Center:**

All-optical thermometry and thermal properties of the optically detected spin resonances of the $NV^-$ center in nano-diamond (55). Below equation provides a path to NV center thermometry after calibrating for $T_D$ and $S$. $DW = e^{-S\left(1+\frac{2}{3}T^2/T_D\right)}$, where S is an electron-phonon coupling parameter and $T_D$ is the Debye temperature for diamond ($T_D$=2220K) (56). Once obtaining $T_D$ and $S$ To determine the temperature of NV center quantum it is necessary to measure the ratio of zero-phonon-line (ZPL) emission relative to the adjacent phonon side bands ($I_{ZPL}/I_{overtone}$). As a proof-of-principle we have used the NV center to measure the temperature of a 10% ytterbium doped lithium yttrium fluoride (Yb:YLF) crystal with nano-diamonds dropcast onto the crystal. The fluoride crystals can be cooled through the efficient emission of upconverted infrared photons excited by a focused 1020 nm laser beam. In Fig. 10a,

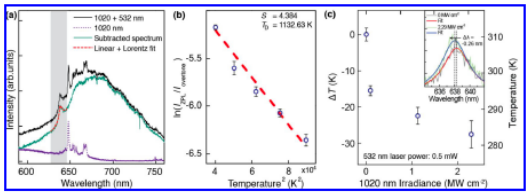
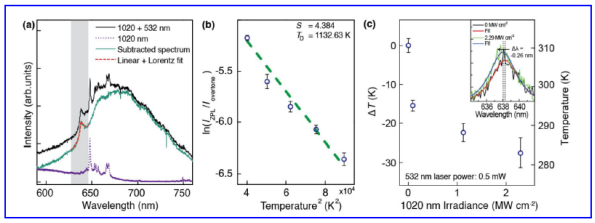



*Figure 10 The composite PL spectrum when both 1020 and 532 nm lasers are on, is shown in black. The contribution from the upconverted $^4F_{9/2}$ emission from $Er^{3+}$ impurity ions is shown using a dotted purple line. The subtracted spectrum and the composite fitting function are shown using a green and dashed red line, respectively. (b) The natural log of DWF is plotted versus the temperature squared. A linear fit (dashed red line) to the data is used to extract TD and S. (c) The corresponding calibrated temperatures obtained from the measured value of $\ln(I_{ZPL}/I_{overtone})$ from the processed spectra are plotted for various laser irradiances of 1020 nm while the 532 nm laser is kept consistently at an irradiance of 0.073 MW.cm$^{-2}$. The inset shows a close up of the background subtracted PL spectra in the ZPL region (~638 nm).*






quantum sensors in both atmospheric and *in vacuo* conditions. Nanodiamonds are attached to ceramic microcrystals including 10% ytterbium doped yttrium lithium fluoride ($Yb:LiYF_4$) and sodium yttrium fluoride ($Yb:NaYF_4$) by van der Waals bonding. The fluoride crystals were cooled through the efficient emission of upconverted infrared photons[10] excited by a focused 1020 nm laser beam. Heat transfer to the ceramic microcrystals cooled the adjacent $NV^-$:NDs by 10 and 27 K at atmospheric pressure and ~$10^{-3}$ Torr, respectively. The temperature of the $NV^-$:NDs was measured using both Debye-Waller factor (DWF) thermometry[11] and optically detected magnetic resonance (ODMR)[12], which agree with the temperature of

Figure 3: (a) The composite PL spectrum, when both 1020 and 532 nm lasers are on, is shown in black. The contribution from the upconverted $^4F_{9/2}$ emission from $Er^{3+}$ impurity ions is shown using a dotted purple line. The subtracted spectrum and the fitting function are shown using a green and dashed red line, respectively. (b) The natural log of the DWF is plotted versus the temperature squared. A linear fit (dashed green line) to the data is used to extract $T_D$ and $S$. (c) The corresponding calibrated temperatures obtained from the measured value of $\ln(I_{ZPL}/I_{overtone})$ from the processed spectra are plotted for various laser irradiances of 1020 nm while the 532 nm laser is kept consistently at an irradiance of 0.073 MW cm$^{-2}$. The inset shows a close up of the background subtracted PL spectra in the ZPL region (~638 nm), and the Lorentzian component of the ZPL fit as the 1020 nm irradiance is increased from 0 and 2.29 MW cm$^{-2}$ are shown in red and blue, respectively.

**Top:** Screen capture from page 13 of Respondent's NSF Proposal (DMR-2046796).[357] **Bottom:** Screen capture from page 2 (left) and page 9 (right) of an arXiv article by Pant *et al*.[358] The screen captures were derived from a copy of Respondent's NSF proposal and Pant et al. that were processed using iThenticate to highlight plagiarized content.

[357] Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf).
[358] Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf).

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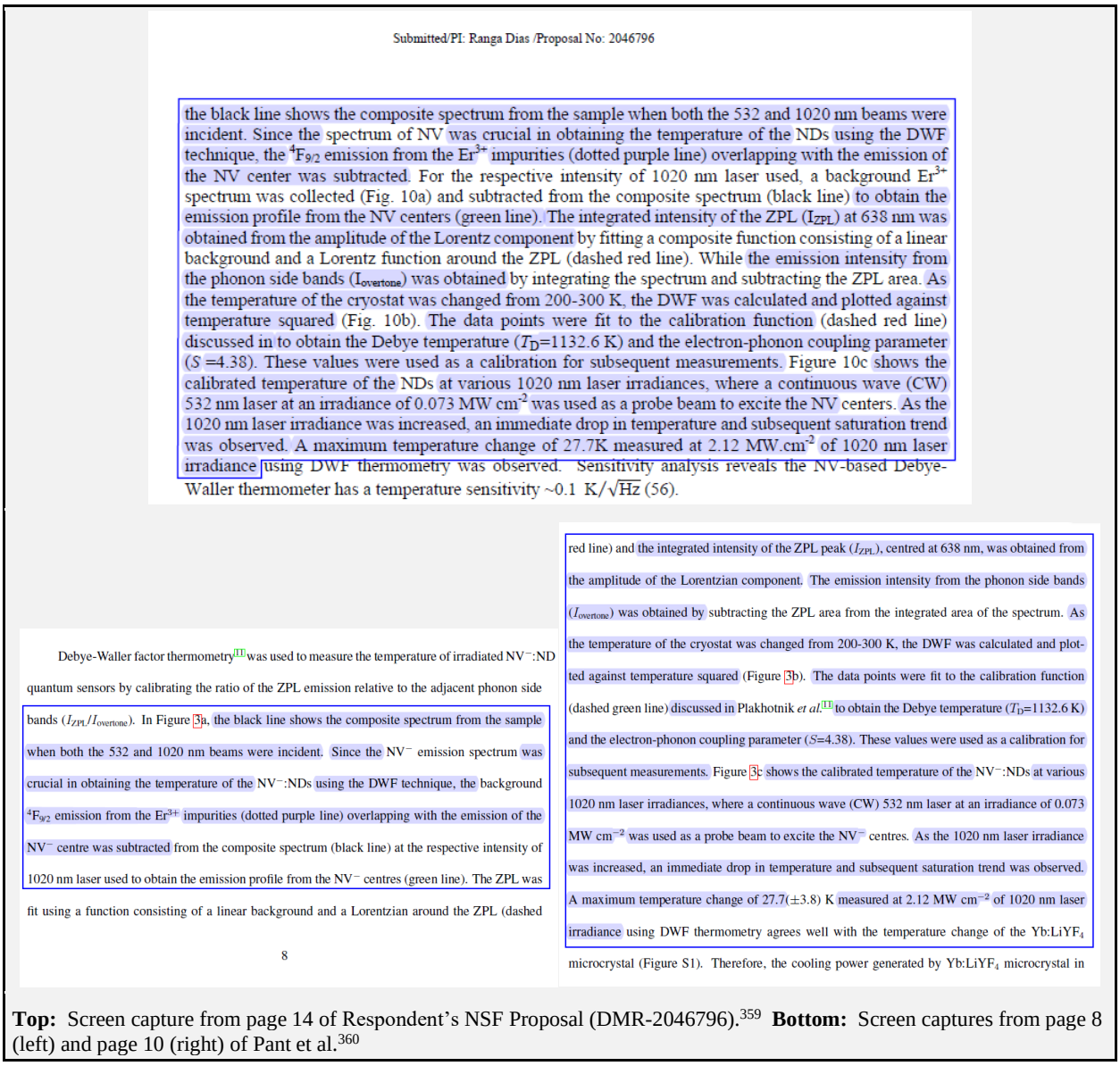

Submitted/PI: Ranga Dias /Proposal No: 2046796

the black line shows the composite spectrum from the sample when both the 532 and 1020 nm beams were incident. Since the spectrum of NV was crucial in obtaining the temperature of the NDs using the DWF technique, the $^4F_{9/2}$ emission from the $Er^{3+}$ impurities (dotted purple line) overlapping with the emission of the NV center was subtracted. For the respective intensity of 1020 nm laser used, a background $Er^{3+}$ spectrum was collected (Fig. 10a) and subtracted from the composite spectrum (black line) to obtain the emission profile from the NV centers (green line). The integrated intensity of the ZPL ($I_{ZPL}$) at 638 nm was obtained from the amplitude of the Lorentz component by fitting a composite function consisting of a linear background and a Lorentz function around the ZPL (dashed red line). While the emission intensity from the phonon side bands ($I_{overtone}$) was obtained by integrating the spectrum and subtracting the ZPL area. As the temperature of the cryostat was changed from 200-300 K, the DWF was calculated and plotted against temperature squared (Fig. 10b). The data points were fit to the calibration function (dashed red line) discussed in to obtain the Debye temperature ($T_D$=1132.6 K) and the electron-phonon coupling parameter ($S$ =4.38). These values were used as a calibration for subsequent measurements. Figure 10c shows the calibrated temperature of the NDs at various 1020 nm laser irradiances, where a continuous wave (CW) 532 nm laser at an irradiance of 0.073 MW $cm^{-2}$ was used as a probe beam to excite the NV centers. As the 1020 nm laser irradiance was increased, an immediate drop in temperature and subsequent saturation trend was observed. A maximum temperature change of 27.7K measured at 2.12 MW.$cm^{-2}$ of 1020 nm laser irradiance using DWF thermometry was observed. Sensitivity analysis reveals the NV-based Debye-Waller thermometer has a temperature sensitivity ~0.1 K/$\sqrt{Hz}$ (56).

Debye-Waller factor thermometry[111] was used to measure the temperature of irradiated $NV^-$:ND quantum sensors by calibrating the ratio of the ZPL emission relative to the adjacent phonon side bands ($I_{ZPL}/I_{overtone}$). In Figure 3a, the black line shows the composite spectrum from the sample when both the 532 and 1020 nm beams were incident. Since the $NV^-$ emission spectrum was crucial in obtaining the temperature of the $NV^-$:NDs using the DWF technique, the background $^4F_{9/2}$ emission from the $Er^{3+}$ impurities (dotted purple line) overlapping with the emission of the $NV^-$ centre was subtracted from the composite spectrum (black line) at the respective intensity of 1020 nm laser used to obtain the emission profile from the $NV^-$ centres (green line). The ZPL was fit using a function consisting of a linear background and a Lorentzian around the ZPL (dashed

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red line) and the integrated intensity of the ZPL peak ($I_{ZPL}$), centred at 638 nm, was obtained from the amplitude of the Lorentzian component. The emission intensity from the phonon side bands ($I_{overtone}$) was obtained by subtracting the ZPL area from the integrated area of the spectrum. As the temperature of the cryostat was changed from 200-300 K, the DWF was calculated and plotted against temperature squared (Figure 3b). The data points were fit to the calibration function (dashed green line) discussed in Plakhotnik *et al.*[111] to obtain the Debye temperature ($T_D$=1132.6 K) and the electron-phonon coupling parameter ($S$=4.38). These values were used as a calibration for subsequent measurements. Figure 3c shows the calibrated temperature of the $NV^-$:NDs at various 1020 nm laser irradiances, where a continuous wave (CW) 532 nm laser at an irradiance of 0.073 MW $cm^{-2}$ was used as a probe beam to excite the $NV^-$ centres. As the 1020 nm laser irradiance was increased, an immediate drop in temperature and subsequent saturation trend was observed. A maximum temperature change of 27.7(±3.8) K measured at 2.12 MW $cm^{-2}$ of 1020 nm laser irradiance using DWF thermometry agrees well with the temperature change of the Yb:$LiYF_4$ microcrystal (Figure S1). Therefore, the cooling power generated by Yb:$LiYF_4$ microcrystal in

**Top:** Screen capture from page 14 of Respondent's NSF Proposal (DMR-2046796).[359] **Bottom:** Screen captures from page 8 (left) and page 10 (right) of Pant et al.[360]

[359] Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf).
[360] Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf).

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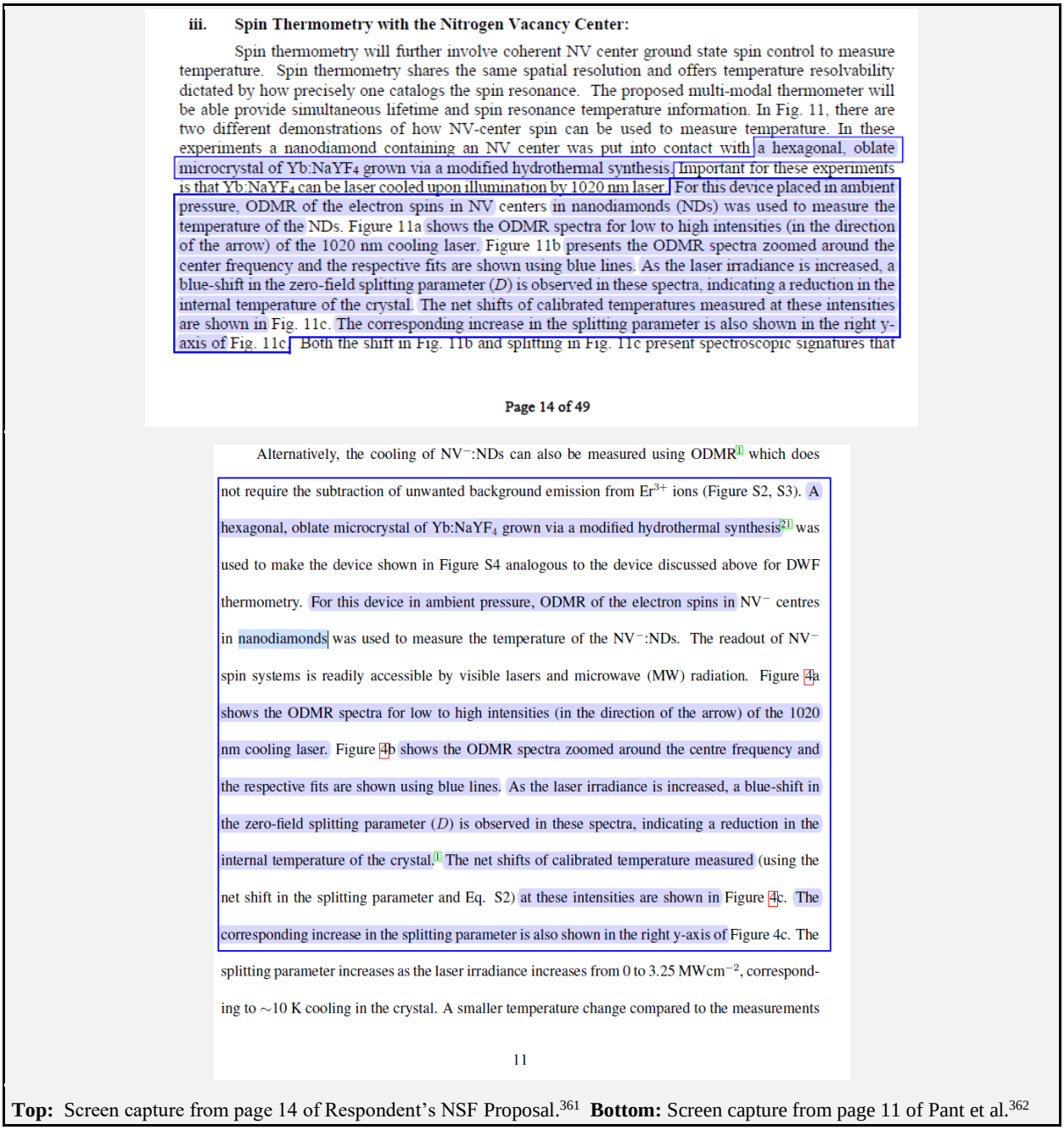

**iii. Spin Thermometry with the Nitrogen Vacancy Center:**

Spin thermometry will further involve coherent NV center ground state spin control to measure temperature. Spin thermometry shares the same spatial resolution and offers temperature resolvability dictated by how precisely one catalogs the spin resonance. The proposed multi-modal thermometer will be able provide simultaneous lifetime and spin resonance temperature information. In Fig. 11, there are two different demonstrations of how NV-center spin can be used to measure temperature. In these experiments a nanodiamond containing an NV center was put into contact with a hexagonal, oblate microcrystal of Yb:$NaYF_4$ grown via a modified hydrothermal synthesis. Important for these experiments is that Yb:$NaYF_4$ can be laser cooled upon illumination by 1020 nm laser. For this device placed in ambient pressure, ODMR of the electron spins in NV centers in nanodiamonds (NDs) was used to measure the temperature of the NDs. Figure 11a shows the ODMR spectra for low to high intensities (in the direction of the arrow) of the 1020 nm cooling laser. Figure 11b presents the ODMR spectra zoomed around the center frequency and the respective fits are shown using blue lines. As the laser irradiance is increased, a blue-shift in the zero-field splitting parameter ($D$) is observed in these spectra, indicating a reduction in the internal temperature of the crystal. The net shifts of calibrated temperatures measured at these intensities are shown in Fig. 11c. The corresponding increase in the splitting parameter is also shown in the right y-axis of Fig. 11c. Both the shift in Fig. 11b and splitting in Fig. 11c present spectroscopic signatures that

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Alternatively, the cooling of $NV^-$:NDs can also be measured using ODMR[1] which does not require the subtraction of unwanted background emission from $Er^{3+}$ ions (Figure S2, S3). A hexagonal, oblate microcrystal of Yb:$NaYF_4$ grown via a modified hydrothermal synthesis[21] was used to make the device shown in Figure S4 analogous to the device discussed above for DWF thermometry. For this device in ambient pressure, ODMR of the electron spins in $NV^-$ centres in nanodiamonds was used to measure the temperature of the $NV^-$:NDs. The readout of $NV^-$ spin systems is readily accessible by visible lasers and microwave (MW) radiation. Figure 4a shows the ODMR spectra for low to high intensities (in the direction of the arrow) of the 1020 nm cooling laser. Figure 4b shows the ODMR spectra zoomed around the centre frequency and the respective fits are shown using blue lines. As the laser irradiance is increased, a blue-shift in the zero-field splitting parameter ($D$) is observed in these spectra, indicating a reduction in the internal temperature of the crystal.[1] The net shifts of calibrated temperature measured (using the net shift in the splitting parameter and Eq. S2) at these intensities are shown in Figure 4c. The corresponding increase in the splitting parameter is also shown in the right y-axis of Figure 4c. The splitting parameter increases as the laser irradiance increases from 0 to 3.25 $MWcm^{-2}$, corresponding to ~10 K cooling in the crystal. A smaller temperature change compared to the measurements

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**Top:** Screen capture from page 14 of Respondent's NSF Proposal.[361] **Bottom:** Screen capture from page 11 of Pant et al.[362]

[361] Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf).
[362] Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf).

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provide value thermometry information. Spin thermometry sensitivity analysis reveals temperature sensitivities ~250 m K/$\sqrt{\text{Hz}}$ (58-61)

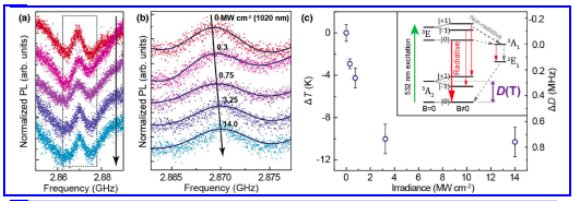


***Figure 11.*** *(a) Full frequency range of ODMR measurements with two* ($m_s$=0↔$m_s$=±1) *resonance dips at* $D(T, g_{\parallel}^{s}) \pm g_{\perp}^{s}$. *The diamond crystal is cooled in the direction of the black arrow. The strained crystal lattice generates a pseudo-magnetic field that gives rise to a broken degeneracy and a splitting between the ground state spin sub-levels* ($g_{\perp}^{s}$). *(b) Variation of the zero-field splitting parameter* $D(T, g_{\parallel}^{s})$ *as a function of the temperature. The ODMR signals, zoomed around 2.87 GHz, show a blue-shift in D revealing the cooling of crystal. The fits are shown in blue. (c) Blue-shift in the splitting parameter D (right y-axis) and the corresponding reductions in the crystal's temperature (left y-axis) versus the cooling power. Inset shows the temperature dependent D-splitting parameter in the context of NV center's energy level system.*

**Instrument construction and calibration**: The first phase of our effort will be to calibrate the temperature and pressure dependence of our NV sensors in a diamond anvil cell. One could imagine three approaches to bringing NV centers proximal to the DAC sample chamber. In approach one (modality **A**) sample of nanocrystals could decorate the culet face, in a second approach (modality **B**) a thin film (microns thick) could be placed onto the internal culet face or NV centers could be ion implanted into the DAC culet directly (modality **C**). All sensor modalities can be fabricated working with industrial vendors and materials processing tools within the URNano facility at Rochester and the Cornell Nanoscale Science and Technology Facility. Importantly, each approach can support a high density (an ensemble) of NV sensors or a low density – as low as one – NV sensor. The density is with respect to the roughly micron sized volume of a diffraction limited confocal microscope. Other microscopy approaches can lead to different sensor volumes and sensor spatial resolution. Sensor density will directly impact measured optical signal and provide bounds for the time resolution of a given architecture.

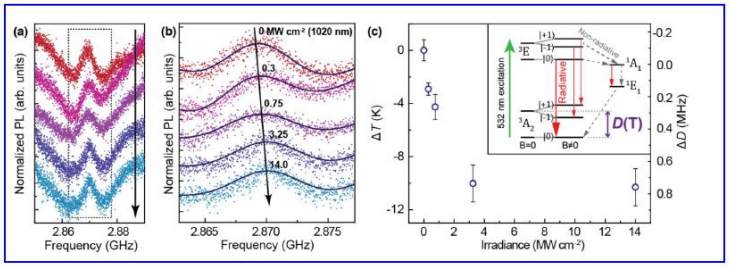


Figure 4: (a) Full frequency range of ODMR measurements with two ($m_s$=0 ↔ $m_s$=±1) resonance dips at $D \pm E$ (Eq. S2); at 1020 nm irradiance of 0, 0.3, 0.75, 3.25, and 14 MW cm$^{-2}$, increasing in the direction of the black arrow. The strained crystal lattice generates a pseudo-magnetic field that gives rise to a broken degeneracy and a splitting between the ground state spin sub-levels. (b) Variation of the zero-field splitting parameter $D$ as a function of the cooling laser irradiance. The ODMR signals, zoomed around 2.87 GHz, show a blue-shift in $D$ revealing the cooling of crystal with increased 1020 nm laser irradiance. The fits are shown in blue. The 1020 nm irradiance increases in the direction of the black arrow; (c) Blue-shift in the splitting parameter $D$ (right y-axis) and the corresponding reductions in the crystal's temperature (left y-axis) versus the irradiance of cooling laser. Inset shows the temperature dependent $D$-splitting parameter in the context of NV$^-$ centre's energy level system. The red arrows represent emission resulting from radiative decay.

**Top:** Screen capture from page 15 of Respondent's NSF Proposal.[363] **Bottom:** Screen capture from page 12 of Pant et al.[364]

[363] Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf).
[364] Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf).

Evidence:

- There are duplicative figures and significant overlapping language across Respondent's NSF Proposal (DMR-2046796) and an arXiv preprint by Pant et al.[365]
- As illustrated in the above comparisons of the NSF Proposal with Pant *et al.*:
  - Large portions of two paragraphs of the NSF Proposal (pages 13-15) are essentially verbatim copied from Pant *et al.* (pages 2 and 8-12).
  - Two figures appearing in the NSF Proposal (Figures 10 and 11) and their captions are essentially copied from Pant *et al.* (Figures 3 and 4).
  - In the preamble to NSF Proposal Figure 10 (page 13) Respondent states: "As a proof-of-principle we have used the NV center to measure the temperature of a 10% ytterbium fluoride (Tb:YLF) crystal with nanodiamonds dropcast onto the crystal." This statement implies that the subsequent work described was done by Respondent, which is untrue because the text and figures following this statement were verbatim copied from Pant *et al.*
  - Respondent deleted citation references from the copied text and changed the figure numbers to integrate the copied figures into the body of the NSF Proposal.
- As discussed earlier in this report, the Investigation Committee found that Respondent's conduct as to **Allegation A.5** constitutes plagiarism in connection with the Nature 2020 (CSH) Paper.

Findings/Reasoning:

Respondent copied, pasted, and integrated significant sections of text and figures from an arXiv manuscript by Pant *et al.*[366] into Respondent's NSF Proposal. According to guidelines from the NSF Office of Inspector General,[367] acts of copying, pasting, and integrating constitutes plagiarism. The question then becomes whether this act of plagiarism was an honest mistake or done with intent. According to these same guidelines, the "additional specific steps to integrate the copied material into the body of a new document [*i.e.*, deleting citation references and changing the figure numbers to match the flow of the NSF Proposal] can help mislead the reader

[365] *See* Anupum Pant, R. Greg Felsted, Alexander B. Bard, Xiaojing Xia, Siamak Dadras, Kamran Shayan, Danika R. Luntz-Martin, Donald Mannikko, Ilia M. Pavlovetc, Stefan Stoll, Masaru Kuno, A. Nick Vamivakas & Peter J. Pauzauskie, *Solid-state laser refrigeration of nanodiamond quantum sensors*, ARXIV (Jul. 30, 2020), https://arxiv.org/abs/2007.15247.
[366] *See* Text Comparison of NSF Career Award Proposal, DMR-2046796 (on file as Proposal - DMR-2046796.pdf); Text Comparison of Pant et al. (on file as Source - arXiv_2007.15247.pdf).
[367] National Science Foundation Office of Inspector General, *Assessing Intent in Verbatim Plagiarism Investigations, available at* https://oig.nsf.gov/sites/default/files/document/2021-10/Assessing%20Intent%20In%20Verbatim%20Plagiarism%20Investigations_0.pdf.

into concluding that the new document is the subject's original work. Those steps can elevate the intent level to intentional."

Conclusion:

The Investigation Committee finds that this instance of plagiarism clearly rises to the level of intentional given that Respondent takes credit for work that was performed by others (Pant *et al.*) without appropriate acknowledgement, engaging in copying, pasting, and integrating. This represents a significant departure from accepted practices within the research community.

The Investigation Committee finds, by a preponderance of the evidence, that Respondent's conduct as to **Allegation E** violated accepted research standards and constitutes research misconduct.

## IV. ADDITIONAL CONSIDERATIONS

This Section IV examines those certain additional considerations specifically called out in the NSF Letter for review during this investigation.

**A. Were Respondent's actions an isolated event or part of a pattern? The investigating official(s) should consider examining other data and research results related to the award, Respondent's other proposals and reports submitted to NSF and other organizations, as well as his publications, for additional falsification and/or fabrication evidencing a pattern.**

This investigation initially focused on the two published articles mentioned in the NSF letter: the Nature 2020 (CSH) Paper and the PRL 2021 ($MnS_2$) Paper. The Investigation Committee uncovered a preponderance of evidence for research misconduct as to several allegations associated with those two papers, including data fabrication and falsification, as described at Section III (Findings) above.

As permitted by the NSF Letter, the Investigation Committee expanded the investigation scope to include additional studies published by Respondent after he joined the University. In doing so, the Investigation Committee uncovered a preponderance of evidence for research misconduct, including plagiarism of text in an arXiv 2021 paper[368] as well as data fabrication and/or falsification in the Chem. Commun. 2022 Paper and in the Nature 2023 (LuH) Paper, as described at Section III (Findings) above.

As requested by NSF, the Investigation Committee also reviewed Respondent's NSF Career Award, uncovering a preponderance of evidence for plagiarism of text and figures therein, as described at Section III (Findings) above.

As of the date of this report, four of these articles have been retracted—the Nature 2020 (CSH) Paper, the PRL 2021 ($MnS_2$) Paper, the Chem. Commun. 2022 Paper, and the Nature 2023 (LuH) Paper.

[368] Ranga P. Dias & Ashkan Salamat, *Standard Superconductivity in Carbonaceous Sulfur Hydride*, v2, ARXIV (Dec. 25, 2021), https://arxiv.org/abs/2111.15017.

An additional article published by the Respondent in *PRL*[369]—that the Investigation Committee did not investigate in detail—has been the subject of an Editorial Expression of Concern dated December 7, 2023, which includes: "Questions have since arisen regarding the origins and integrity of the transport data in Figs. 1(c), 2, 3, S10(b), and S13, and Table S1. At this juncture, we are investigating these concerns with the cooperation of the authors."[370] This is consistent with the testimony of three former students in Respondent's lab, who stated that the low temperature resistance versus temperature data reported in this article had not been measured in the Respondent's laboratory at the University.[371] Interviewee 7 informed the Investigation Committee that he and other co-authors, including former members of Respondent's lab, are in the process of contacting *PRL* to initiate retraction of that paper, for similar reasons.[372] Accordingly, if these additional papers are retracted ultimately, there will be a total of five recent retractions of Respondent's work.

The above events evidence a clear pattern of inappropriate research practices constitutive of research misconduct.

**B. Did Respondent's actions have a significant impact on the research record, research subjects, other researchers, institutions, or the public welfare? If yes, please describe how.**

Respondent's actions are bound to have significant impact on the career development of former and current students and research faculty. One of Respondent's former students (Interviewee 8) is a co-author on all four of the papers investigated by this committee, while another (Interviewee 3) was a co-author on three papers, three others (Interviewee 5, Interviewee 6, and another student) were co-authors on two papers, and several others were co-authors on at least one of these papers. Four of these papers have now been retracted. As mentioned earlier in this report, a fifth paper is being considered for retraction (author-led retraction by Interviewee 7); this paper also involves some of these students as co-authors (Interviewee 8, Interviewee 3, and Interviewee 6). These retractions, occurring at a point early in their careers, could have a significant and negative impact on these students' career development. Many of the students have not yet graduated and they now have little to show for their activities in Respondent's lab (which currently lists 11 students).[373] It is difficult to assess the long-term effects of Respondent's actions for each individual.

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[369] Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Xiaoyu Wang, Noah Meyers, Keith V. Lawler, Eva Zurek, Ashkan Salamat & Ranga P. Dias, *Synthesis of Yttrium Superhydride Superconductor with a Transition Temperature up to 262 K by Catalytic Hydrogenation at High Pressures*, PHYS. REV. LETT. 126, 117003 (Mar. 19, 2021), https://doi.org/10.1103/PhysRevLett.126.117003.

[370] *See* Interviewee 7 Interview (Oct. 2, 2023) 50:2-51:11; Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Xiaoyu Wang, Noah Meyers, Keith V. Lawler, Eva Zurek, Ashkan Salamat & Ranga P. Dias, *Expression of Concern: Synthesis of Yttrium Superhydride Superconductor with a Transition Temperature up to 262 K by Catalytic Hydrogenation at High Pressures [Phys. Rev. Lett. 126, 117003 (2021)]*, PHYS. REV. LETT. 131, 239902 (Dec. 7, 2023), https://doi.org/10.1103/PhysRevLett.131.239902.

[371] Interviewee 6 (Jul. 20, 2023) 19:5-20:6; Interviewee 6 Interview (Aug. 16, 2023) 16:15-17:1; Interviewee 8 Interview (Jul. 20, 2023) 30:3-31:17; Interviewee 9 Interview (Jul. 31, 2023) 33.

[372] *See* Interviewee 7 Interview (Oct. 2, 2023) 50:2-8.

[373] *See* Letter from Respondent to Stephen Dewhurst (Jun. 16, 2023), titled Re: Investigation Referred from National Science Foundation ("NSF"), in Exhibit H.

Respondent has knowingly deceived his senior co-authors at UNLV and at other institutions by injecting fabricated or falsified data into their collaborative efforts. In so doing, Respondent has contaminated those co-authors' otherwise productive work on other aspects of their research topics. As the joint work came under scrutiny, Respondent continued to deceive his colleagues by supplying data and explanations based on additional levels of fabrication (exemplified in both the Nature 2020 (CSH) Paper and the PRL 2021 ($MnS_2$) Paper). Interviewee 7, in particular, has spent a significant amount of time defending the retracted work because of misplaced trust in Respondent and his work. In one instance, Interviewee 7 enlisted a UNLV coworker, Dr. Andrew Cornelius,[374] to support the defense of the $MnS_2$ work. The falsified data provided by Respondent was intended to mislead the scientific community, Interviewee 7, Dr. Cornelius, and the post-publication reviewers at *PRL*.

Because high-temperature superconductivity, if confirmed, could have an enormous impact on fundamental science and on many technologies, Respondent's claims have spurred widespread (*i.e.*, international), parallel investigations of superconductivity in pressurized CSH and LuH. None of these studies to date have resulted in published peer-reviewed confirmation of Respondent's claims for room temperature superconductivity in CSH or LuH. Aside from the direct misuse of government-funded research resources by Respondent, these outside efforts represent a large amplification of funding misuse, as these outside researchers, also funded by government agencies, have spent significant resources attempting to confirm the original claims that were based on fabricated or falsified data. Respondent also has misused funding from private sources, including the Moore Foundation.

The bold claims of Respondent's publications have garnered intense media coverage,[375] which has been amplified by other scientists disputing the claims.[376] This will continue as the extent

[374] *See* Andrew Cornelius, *My Take on the Recent Salamat/Dias Misconduct Allegations* (on file as Misconduct Reply public version by Andrew Cornelius.pdf); *see also* Andrew Cornelius, Ranga P. Dias & Ashkan Salamat, *Sur-Response in Opposition to Dr. Hamlin's Accusations of Data Copying in "Colossal Density-Driven Resistance Response in the Negative Charge Transfer Insulator $MnS_2$ as Reported in previously published in Physical Review Letters (doi.org/10.1103/PhysRevLett.127.016401)* (on file as PRL Response re Analysis of JH Paper Final.pdf).

[375] *See, e.g.*, Kenneth Chang, *Finally, the First Room-Temperature Superconductor*, THE N.Y. TIMES (Oct. 14, 2020), https://www.nytimes.com/2020/10/14/science/superconductor-room-temperature.html; Kenneth Chang, *New Room-Temperature Superconductor Offers Tantalizing Possibilities*, THE N.Y. TIMES (Mar. 8, 2023), https://www.nytimes.com/2023/03/08/science/room-temperature-superconductor-ranga-dias.html; Aylin Woodward, *The Scientific Breakthrough That Could Make Batteries Last Longer*, THE WALL STREET JOURNAL (Mar. 8, 2023), https://www.wsj.com/articles/superconductor-breakthrough-energy-reddmatter-90dfa165; Dan Garisto, *Allegations of Scientific Misconduct Mount as Physicist Makes His Biggest Claim Yet*, PHYSICS (Mar. 9, 2023), https://physics.aps.org/articles/pdf/10.1103/Physics.16.40; Davide Castelvecchi & Nature Magazine, *Nature Retracts Controversial Room-Temperature Superconductor Study*, SCIENTIFIC AMERICAN (Nov. 8, 2023), https://www.scientificamerican.com/article/nature-retracts-controversial-room-temperature-superconductor-study/.

[376] *See, e.g.*, Dirk van der Marel & Jorge E. Hirsch, *Extended Comment on Nature 586, 373 (2020) by E. Snider et al*, ARXIV (2022), https://arxiv.org/abs/2201.07686; James J. Hamlin, *Vector graphics extraction and analysis of electrical resistance data in Nature volume 586, pages 373-377 (2020)*, ARXIV (2022), https://arxiv.org/abs/2210.10766; Dirk van der Marel & Jorge E. Hirsch, *Room-temperature superconductivity – or not? Comment on Nature 586, 373 (2020) by E. Snider et al.*, INT. J. MOD. PHYS. B 27, No. 04, 2375001 (2023), https://www.worldscientific.com/doi/10.1142/S0217979223750012; "RETRACTED ARTICLE: Evidence of near-ambient superconductivity in a N-doped lutetium hydride," PUBPEER, https://pubpeer.org/publications/5B50A0D3400CDD252EC67D75F0841A; Virtual Science Forum, *Extracting Data from Scientific Publications: Virtual Science Forum on Reproducibility in Condensed Matter Physics*, YOUTUBE (Mar. 9, 2023), https://www.youtube.com/watch?v=ps2JqdrzwcM&t=1s.

Respondent's research misconduct becomes more broadly known. Such news is sure to be very confusing and damaging for the image of science in the eyes of the public.

All three institutions with which Respondent has been affiliated (WSU, Harvard University ("Harvard"), and the University) have trained many scientists currently employed at U.S. DOE National Laboratories, including several scientists involved in missions related to national security. It is concerning that activities involving research misconduct by Respondent have taken place undetected at these institutions, over a period spanning more than a decade. The quality and integrity of the scientific staff and training at U.S. institutions is often cited as a key component of the national security enterprise. The misconduct uncovered in this investigation may damage, by association, the reputation of this enterprise in the eyes of allies and adversaries alike.[377]

### C. Has Respondent received or participated in any training in the responsible and ethical conduct of research or other training relevant to the acts that are the subject of your investigation? If yes, please describe that training.

WSU policy indicates that a mandatory training in ethical conduct of research was in place for all graduate students by the time Respondent began his PhD studies at WSU (2009).[378] However, Respondent declared that he did not recall any formal training in the responsible and ethical conduct of research.[379]

## V. REVIEW OF RESPONDENT'S RESPONSE TO DRAFT INVESTIGATION REPORT

On January 30, 2024, Respondent submitted a 218-page response to the Investigation Committee's draft report (the "Response," attached hereto as Exhibit J). The Response does not address allegations associated with the Nature 2020 (CSH) Paper (Allegations A.1–A.5), the PRL 2021 ($MnS_2$) Paper (Allegations B.1 and B.2), or the NSF Early Career Award Proposal (Allegation E). Of those Allegations addressed by Respondent (Allegations C and D.1–D.7), very little of the Response directly addresses the evidence cited to or findings of the Investigation Committee. In many instances, Respondent provides information that is irrelevant to the investigation, such as datasets with $MgB_2$ measurements, figures extracted from published work of other researchers, a tutorial on curve fitting with MATLAB, a compilation of proprietary material (Appendix II to the Response), and similar other miscellany.

The Investigation Committee wishes to highlight several general issues and themes based on its review of the Response.

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[377] *See, e.g.*, Ling Xin, *US team retracts bombshell superconductor study after Chinese researchers challenge findings*, SOUTH CHINA MORNING POST (Nov. 18, 2023), https://www.scmp.com/news/china/science/article/3241709/us-team-retracts-bombshell-superconductor-study-after-chinese-researchers-challenge-findings.

[378] Washington State University, Policies and Procedures Manual 77 (2009), https://confluence.esg.wsu.edu/pages/viewpage.action?pageId=266603505 (accessible under "2009-2010," under Archived Policies and Procedures) ("Mandatory training on the Responsible Conduct of Research is required of all graduate students, and it is an employment requirement for graduate assistants.").

[379] R. Dias Interview (Jul. 7, 2023) 71:6-72:14.

- Respondent does not share any raw, original data with the Investigation Committee in the Response.
- Respondent continues to point to data and findings published subsequent to the works at issue in this investigation. Accordingly, the Investigation Committee again emphasizes, to Respondent in particular, that such data have no bearing on the Investigation Committee's reasoning or findings. The Investigation Committee's charge was not to examine whether the scientific theories underlying the allegations are correct, but rather whether the allegations meet the criteria for research misconduct.
- Throughout the Response, Respondent posits that the Investigation Committee's access to sequestered materials shows the Respondent's own cooperation in the investigation process and that the Investigation Committee should be able to locate all relevant files within those sequestered materials. However, such reasoning is flawed: (1) for the majority of sequestered materials, Respondent's cooperation was not required to gain access; (2) access to such a large volume of sequestered materials does not equate to an ability to pinpoint all relevant files, even through diligent search efforts; (3) it is Respondent's responsibility—not the Investigation Committee's—to identify data in support of his published work, even though the Investigation Committee has made diligent efforts to identify any such data from among sequestered materials; and (4) Respondent did not, in fact, point the Investigation Committee to all relevant files or otherwise send copies of all relevant files for the Investigation Committee's review.

As summarized below, the Investigation Committee examined and assessed on the merits the Response—which, as noted above, addresses only 8 of the 16 allegations investigated by the Investigation Committee.

**Response to Allegation D.1 Findings – Falsification and/or Fabrication of Figure 2a, R(T) Data.**[380] In the Response, Respondent provides no information or evidence to counter the Investigation Committee's finding that the "source data" provided to *Nature* reviewers and the public were manipulated in three different ways: subtraction, selective omission, and resampling. Indeed, Respondent admitted that the data had to be corrected, citing the need for "phase corrections." This justification for manipulation has no bearing on this issue because source data are, by definition, unprocessed and uncorrected. Neither Respondent nor any of his students discussed "phase corrections" during interviews, and these are not discussed in any of the published articles. While a "phase correction" seems to explain what appears to be a small shift in temperature between the published data and the sequestered data for the R(T) curve at 20 kbar,[381] "phase corrections" cannot explain what appears as subtraction of a large fraction of signal at lower temperatures for the R(T) curves at 16 kbar[382] and 10 kbar.[383] Nor does Respondent's explanation have any bearing on the omission of data below ~235 K for R(T) at 20 kbar and below ~100 K for R(T) at 16 and 10 kbar.

[380] *See* the Response at 20–53.
[381] *See* Figure LuH_8 at **Allegation D.1** (above); and Figure 17 in the Response at 37.
[382] *See* Figure LuH_6 of **Allegation D.1** (above); and Figure 18 in the Response at 39.
[383] *See* Figure LuH_3 of **Allegation D.1** (above); and Figure 24 in the Response at 44.

**Response to Allegation D.2 Findings – Falsification and/or fabrication of Extended Data Figure 13a, R(T) data.**[384] In the Response, Respondent provides no information or evidence to counter the Investigation Committee's finding that the "source data" provided to the public were manipulated to omit the erratic resistance jumps at low temperatures. Respondent's invocation of baroque explanations to interpret, and therefore justify, the omission of these data does not alter the Investigation Committee's reasoning or findings. The editors, reviewers, and readers of the article likely would have different explanations for the observed signals if they had access to the complete, unaltered source data.

**Response to Allegation D.3 Findings – Falsification and/or fabrication of Extended Data Figure 15, R(T) data.**[385] Respondent has not provided the source data for this figure to *Nature* editors and reviewers (pre-publication or post-publication) nor to the Investigation Committee. Neither the post-publication reviewers nor the Investigation Committee were able to reproduce the originally published figure or the revised version of this figure based on the processed (not raw) data provided by Respondent. The Response does not alter these facts. In addition, the Respondent's forceful statement that 0.02 Volts divided by 0.002 Amperes is equal to 10 milli-Ohms is demonstrably false given that 1 Ohm is equal to 1 Volt divided by 1 Ampere.[386]

**Response to Allegation D.4 Findings – Fabrication and/or falsification of Figure 4, C(T) data.**[387] In the Response, Respondent does not provide clear evidence that counters the Investigation Committee's reasoning and findings that the "source data" provided to *Nature* reviewers and the public were manipulated. The Investigation Committee independently identified within sequestered records what appear to be the actual source data underlying Figure 4c, which enabled the Investigation Committee to verify the manipulation. Respondent's invocation of the need for "phase corrections" to justify these manipulations has no basis in the physics of the measurement and does not alter the fact that Respondent concealed source data from *Nature* editors and referees as well as readers and presented altered data as "source data."

**Response to Allegations D.5 and D.6 Findings – Fabrication and/or fabrication of Figures 3a and 3b, M(T) and M(H) data.**[388] In the Response, Respondent claims that the Investigation Committee's interpretation of the PPMS data is incorrect, stating "it is important to clarify that the discrepancies in interpretation arose due to the highly inhomogeneous nature of our samples and the challenges associated with obtaining accurate measurements with larger samples, as opposed to DAC experiments where diamonds were used."[389] In particular, Respondent disagrees with the Investigation Committee's assessment that the sample is centered within the PPMS measurement coils at a location of 33 mm, and rather claims that the sample is centered within the PPMS measurement coils at a location of 29 mm. As evidence for this claim, Respondent appeals to an M(H) curve obtained at the 29 mm location at 10 K, which appears to exhibit the Meissner effect.[390]

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[384] *See* the Response at 54-68.
[385] *See* the Response at 68-79.
[386] *See* the Response at 69.
[387] *See* the Response at 79-92.
[388] *See* the Response at 92-123.
[389] *See* the Response at 96 and (repeated verbatim) 113.
[390] *See* Figure 12 of the Response at 122.

There are at least two problems with Respondent's argument.

- First, the PPMS measurements obtained on the "Fourth Sample" (which the Investigation Committee confirmed corresponds to the data shown in Figure 3a of the Nature 2023 (LuH) Paper) clearly indicate that the sample is centered within the PPMS measurement coils at a location of 33 mm. Furthermore, only one of the 42 M(H) curves obtained on the "Fourth Sample" (at various locations from 29 to 34 mm and various temperatures from 10 to 300 K) exhibits behavior suggestive of the Meissner effect. Examining the totality of the evidence, it is much more likely that this single curve at 29 mm and 10 K is representative of the cell material at 10 K, which is strongly diamagnetic—*i.e.*, the sample material at this location is outside the PPMS measurement coils.
- Second, Respondent does not explain why he used data from a location of 31 mm to produce the FC data shown in Figure 3a of the Nature 2023 (LuH) Paper (Respondent used data from a location of 31 mm as the sample and 33 mm as the background), yet Respondent used data from a location of 29 mm to produce the ZFC data shown in Figure 3a of the Nature 2023 (LuH) Paper (Respondent used data from a location of 29 mm as the sample and 33 mm as the background). If the sample really was centered within the PPMS measurement coils at a location of 29 mm, data from that location should have been used to produce both the ZFC and FC data shown in Figure 3a.

Respondent provides no additional information or evidence to counter the Investigation Committee's finding that Respondent chose particular data traces to fabricate plausible ZFC and FC curves having characteristics of both the expected superconducting response and of PPMS measurements (*e.g.*, resolution, noise, and temperature series).

**Response to Allegation D.7 Findings – Fabrication and/or falsification of Figure 1a, $T_c$(P) data.**[391] In the Response, Respondent identifies four data files generated by the Origin data analysis application.[392] Of the more than 130 data tables contained in these files, only 13 datasets are relevant, which correspond to the 13 plots at pages 128–130 of the Response that show resistance versus temperature or voltage versus temperature that exhibit sudden drops in resistance or voltage under decreasing temperature. These plots are purportedly the underlying measurement data used by Respondent to infer the relevant $T_c$ data points shown in Figure 1a of the Nature 2023 (LuH) Paper. However, these newly identified Origin files are not raw source data. Respondent does not provide a detailed set of raw data files, and Respondent has neither identified these files in the sequestered data nor identified any other records associated with these $T_c$ data points. Therefore, Respondent does not provide evidence to counter the Investigation Committee's findings and conclusions with regard to Allegation D.7.

**Response to Allegation C – Fabrication and/or falsification of Figure 1a and Figure S13, R(T) data.**[393] In the Response, Respondent states: "My role in the preparation of the paper was confined to assisting with the sample and providing the data."[394] All co-authors agree that Respondent provided the R(T) data used to prepare the Chem. Commun. 2022 Paper, yet to date

[391] *See* the Response at 123-134.
[392] Origin app, *available at* https://www.originlab.com/apps.
[393] *See* the Response at 142-161.
[394] *See* the Response at 157.

Respondent has not provided unaltered, raw datasets corresponding to the R(T) data in the article, as previously requested by the Investigation Committee, and Respondent has not indicated where—if anywhere—among the sequestered files such data may be found. Accordingly, Respondent has provided no evidence to counter the Investigation Committee's conclusion, based on its thorough review of available evidence, that the published data were fabricated and/or falsified.

## VI. RECOMMENDATIONS AND CLOSING THOUGHTS

Based on the observations and findings described above, the Investigation Committee recommends that the University consider taking the following actions with respect to Respondent and his research:

- **Consider issuing a public statement summarizing the findings of this Investigation.** The issues considered in this report have already appeared in the public media, including through public statements issued by Respondent and not through any leak of information from the University or the Investigation Committee. Accordingly, while the Investigation Committee is respectful of the confidentiality of this matter, it also believes that, in light of the public awareness of this matter and the important scientific issues raised, a public statement would contribute to restoration of the public's trust in the integrity and excellence of research at the University and in the U.S. scientific community.
- **Limiting mentorship, teaching, and supervision responsibilities, as well as funding opportunities.** The Investigation Committee recommends that Respondent not be permitted to teach students, to mentor students, or to supervise students at any level, either in the classroom or within a research laboratory; to supervise junior research faculty; or to carry out independent research funded by government agencies or private entities (whether industry or philanthropic). Within the University, Respondent's position of Assistant Professor implies that he can be trusted, can serve as a good role model, can serve as a mentor, and can lead a research team. Evidence uncovered in this investigation shows that Respondent cannot be trusted, has served as a poor role model, has been a poor mentor, and has shown poor leadership while running his research team. This includes evidence of Respondent dismissing the concerns of his students and, since the commencement of this investigation, certain behavior of Respondent toward his now-former students and collaborators that may be seen as harassment and/or bullying. Respondent has displayed similar behavior towards his peers, by misleading them in their research collaborations and by misleading peer reviewers and journal editors. Based on the multiple misconduct findings of this report, Respondent has misused public and private funds and caused amplification of this misuse by spurring workers at other institutions to investigate Respondent's public misrepresentations. While the Investigation Committee understands that personnel decisions are within the University's purview, the Investigation Committee acknowledges that these recommendations are tantamount to a recommendation of termination.
- **Continue to follow up with affected journals.** The Investigation Committee recommends that the University continue to communicate with affected journals, including those that have already issued retractions of affected Papers, to the extent these journals have additional questions for, or need additional information from, the University, or if the University learns

of information, subsequent to this report, that may be pertinent to the affected Papers, even if retracted.

- **Reach out to other funders.** The Investigation Committee recommends that the University reach out to other funders of Respondent's work, including the DOE and the Moore Foundation, given that the Investigation Committee's findings concern work that was supported, at least in part, by these funders.

- **Reach out to Respondent's previous institutions.** The Investigation Committee recommends that the University reach out to WSU and Harvard to inform these institutions of the outcome of this investigation. Respondent was a graduate student (2009–2013) and a postdoctoral researcher (Sept. 2013–April 2014) with Dr. Choong-Shik Yoo at WSU and a postdoctoral fellow with Dr. Isaac Silvera at Harvard (June 2014–June 2017) before joining the University as an Assistant Professor in July 2017. The Investigation Committee's reasoning for this recommendation is as follows:

  - Although not the focus of this investigation, Respondent also has been accused of plagiarism in connection with his PhD dissertation (a revised version of Respondent's PhD dissertation dated September 2023 is now publicly available on WSU's repository).[395] Dr. Hamlin and Dr. Simon Kimber, a physicist most recently at the University Burgundy Franche-Comté (and co-author on the PRL 2021 ($MnS_2$) Paper), compiled a side-by-side comparison of Respondent's original PhD dissertation and 18 different publications by various authors that clearly shows significant overlapping language throughout Respondent's PhD dissertation and those prior publications.[396]

  - A high-profile publication in *Science*,[397] published while Respondent was a postdoctoral researcher at Harvard, has attracted strong criticism from other experts in the field and the results of this publication have not been accepted by nearly all expert peers.[398] Examination of the data files made publicly available as Supplementary Materials for the Respondent's article published in *Science*,[399] and of the *Technical Comments*[400] reveal

[395] *See* Section V (Recommendations).
[396] The comparison of Respondent's PhD dissertation with various publications by Drs. Hamlin and Kimber, *available at* https://www.science.org/do/10.1126/science.adi2603/full/dias_thesis_report_visualization.pdf.
[397] Ranga P. Dias & Isaac F. Silvera, *Observation of the Wigner-Huntington transition to metallic hydrogen*, SCIENCE 355, 715 (Jan. 26, 2017), https://doi.org/10.1126/science.aal1579.
[398] *See, e.g.,* Xiao-Di Liu, Philip Dalladay-Simpson, Ross T. Howie, Bing Li & Eugene Gregoryanz, *Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen*, SCIENCE 357, eaan2286 (Aug. 25, 2017), https://doi.org/10.1126/science.aan2286; Alexander F. Goncharov & Viktor V. Struzhkin, *Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen*," SCIENCE 357 (Aug. 25 2017), https://doi.org/10.1126/science.aam9736; Paul Loubeyre, Florent Occelli & Paul Dumas, *Comment on: Observation of the Wigner-Huntington transition to metallic hydrogen*, ARXIV (2017), https://doi.org/10.48550/arXiv.1702.07192.
[399] *See* Ranga P. Dias & Isaac F. Silvera, *Observation of the Wigner-Huntington transition to metallic hydrogen*, SCIENCE 355, 715 (Jan. 26, 2017), https://doi.org/10.1126/science.aal1579.
[400] *See* Xiao-Di Liu, Philip Dalladay-Simpson, Ross T. Howie, Bing Li & Eugene Gregoryanz, *Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen*, SCIENCE 357, eaan2286 (Aug. 25, 2017), https://doi.org/10.1126/science.aan2286; *see also* Alexander F. Goncharov & Viktor V. Struzhkin, *Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen*," SCIENCE 357 (Aug. 25, 2017), https://doi.org/10.1126/science.aam9736.

puzzling inconsistencies in the optical reflectivity data and infrared spectroscopy not satisfactorily resolved by the authored *Technical Responses.*[401]

- Multiple public comments on *PubPeer* detail striking similarities between various Raman spectroscopy and electrical conductivity datasets for OCS, $SnS_2$, and $SiS_2$ reported in Respondent's publication in *Scientific Reports*,[402] Respondent's PhD dissertation, and data shown during a seminar at Brown University.[403]
- A revised version (dated September 2023) of Respondent's PhD dissertation has been made available on the WSU repository.[404] Comparison of the original and revised PhD dissertations reveal significant modifications to figures reporting original experimental results:
  - Figure B4 was deleted. Figure B4 reported low temperature R(T) data on $GeSe_4$ at various pressures. Three of these R(T) curves were involved in fabrication by Respondent in the PRL 2021 ($MnS_2$) Paper (**Allegation B.1**).
  - Figure C1 was deleted. Figure C1 reported room temperature R(P) data on $SnO_2$.
  - Figure 5.10 was updated with curves bearing no resemblance to the original. Figure 5.10 reported low temperature R(T) data on $SnS_2$ at various pressures.

In closing, the Investigation Committee would like to acknowledge the active cooperation of former members of the Respondent's laboratory at the University, who provided candid, detailed information regarding the conduct of research and the preparation of publications in the Respondent's laboratory. A fulsome investigation would not have been possible without the express cooperation of these individuals.

In this proceeding, the Investigation Committee regarded itself has having jurisdiction over those carrying out work while at the University, including students and junior faculty who worked in Respondent's laboratory. Based on the Investigation Committee's interactions with and materials obtained from those students and junior faculty associated with Respondent's laboratory, the Investigation Committee, in its judgment, does not regard those individuals as culpable in this matter. Rather the Investigation Committee views the other members of Respondent's laboratory as victims, having been intentionally misled by Respondent. With regard to other collaborators of Respondent outside the University, the Investigation Committee did not have full access to all materials, correspondence, or other resources of those individuals or their institutions. However, based on the evidence to which the Investigation Committee did

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[401] Isaac F. Silvera & Ranga Dias, *Response to Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen,"* SCIENCE 357 (Aug. 25, 2017), https://doi.org/10.1126/science.aan2671; Isaac F. Silvera & Ranga Dias, *Response to Comment on "Observation of the Wigner-Huntington transition to metallic hydrogen,"* SCIENCE 357 (Aug. 25, 2017), https://doi.org/10.1126/science.aan1215.

[402] Minseob Kim, Ranga Dias, Yasuo Ohishi, Takehiro Matsuoka, Jing-Yin Chen & Choong-Shik Yoo, *Pressure-induced Transformations of Dense Carbonyl Sulfide to Singly Bonded Amorphous Metallic Solid*, SCI. REP. 6, 31594 (2016), https://doi.org/10.1038/srep31594.

[403] Brown University Department of Physics, *"Metallic Hydrogen" Ranga Dias, Harvard University*, YOUTUBE (Feb. 20, 2017), https://www.youtube.com/watch?v=BnNBTB5aKZQ.

[404] Revised September 2023 Version of Ranga P. Dias, *Phase Transitions, Metallization, Superconductivity and Magnetic Ordering in Dense Carbon Disulfide and Chemical Analogs* (Jul. 2013) (PhD Dissertation, Washington State University), *available at* https://rex.libraries.wsu.edu/esploro/outputs/doctoral/PHASE-TRANSITIONS-METALLIZATION-SUPERCONDUCTIVITY-AND-MAGNETIC/99900581648701842.

have access, it did not find significant or substantial evidence of wrongdoing by such individuals whose work is based outside the University.

The Investigation Committee also would like to acknowledge support from the University in facilitating logistical aspects of this investigation.

[*Signature Page Follows*]

***CONFIDENTIAL***

Peter M. Celliers Digitally signed by Peter M. Celliers Date: 2024.02.08 14:48:06 -08'00'

Peter Celliers, PhD

Knudson, Marcus David Digitally signed by Knudson, Marcus David Date: 2024.02.08 15:39:16 -07'00'

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